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CONTENTS

Rotary Drilling Rigs
By Charles T. Reichert

Medical Services in the Oil Industry
By S. D. McClean, M.R.C.P.

and

Medical Facilities on Far Eastern Oilfields
By F. L. Webster, F.R.C.S.Ed.

Hydrocarbon Research Group Report for 1953

Abstracts 1732–1853

Book Review

Additions to Library

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THE INSTITUTE OF PETROLEUM

AN Ordinary General Meeting of the Institute of Petroleum was held at 26 Portland Place, London, W.1, on 29 April 1954, the Chair being taken by E. C. Masterson, B.Sc.

The Editor read the minutes of the previous meeting, which were confirmed and signed as a correct record. He then read the list of members elected since the previous meeting, and made various announcements.

The Chairman, introducing the author of the paper to be presented, said: I wonder whether it is generally appreciated what great improvements have been made to rotary drilling equipment over the past thirty years. I started my oil career in Rumania about thirty-four years ago, and it was the practice in my company for all new arrivals to work for the first twelve months on a drilling rig.

When reading the pre-print of the paper in which the latest type of drilling equipment is discussed, I tried to picture the type of rig on which I spent my first twelve months. I recall a two-shaft rig with 5-inch drum shaft and a 4-inch shaft supported on three wooden posts. There were two clutches on the drum shaft—a knee clutch and a foot clutch—and I am sure there are a number of people who have reason to remember the knee clutch of those early rigs. When trying to engage these clutches one frequently received a severe kick-back, and it was said that a man was not a qualified driller until he had had at least three stiff legs.

I remember the brakes on my first rig. The brake bands were provided with wooden blocks, and it was quite a job to hold more than about 2000 ft of drill pipe. As a result of a wound, my right arm is not particularly strong, and I recall that it took two of us to handle the brake when the well passed 2500 ft in depth.

I also remember the 10 × 10-inch single-cylinder steam-engine, which powered the rig, and those of you who have drilled with this type will recall the frequent occasions on which it stopped on dead centre, and how one of the men on the derrick floor would frequently have to run back and kick the engine off centre. Some of the present-day safety engineers would hardly approve such practices!

Then again I think of the old Mogul pump with its crow's feet holding down the eight pot covers. If the driller applied too much weight on the bit, the pump pressure would go up and the gaskets under the pot covers would invariably fail and drench everybody on the derrick floor. I think also of the cast-iron catheads with their well-worn grooves, the 16-inch chain tongs, used as back-up tongs, and many other parts of the rig which in comparison with a modern outfit is like comparing a Model T Ford of the 1920s with the present-day automobile.

Thus, you will not want to hear any more about the rig that was in use thirty-four years ago, but something about the equipment in use today and perhaps also an indication of future trends in drilling rig manufacture. I do not believe there is anyone more qualified to tell us about this than Mr Reichert, who has had, as you know, almost forty years' experience with the National Supply Company of America. During the second world war Mr Reichert was Director of Materials for the Pacific Coast for the Petroleum Administration for War, and at the beginning of the Korean conflict he was recalled to Washington as Chief of the Drilling Equipment Section of the Petroleum Administration for Defence. He is also a member of the National Association of Foreman, the Californian National Gasoline Association, and the Petroleum Production Pioneers.

The following paper was then presented in summary by the author:

ROTARY DRILLING RIGS

By CHARLES T. REICHERT*

SUMMARY

A brief review of the development of rotary equipment for oil well drilling, with descriptions of the various units which comprise today's drilling rig, the functions of each, and the points to be considered in the selection of suitable combinations of these components.

INTRODUCTION

ROTARY drilling equipment was first used in about 1880, and was prominent a few years later in the development of the Corsicana field, where it was operated with water as the circulating fluid. The rotary system was also employed in drilling the discovery well in the Spindletop field in 1901, and it is reported that the first use of mud as the circulating medium was in this well. According to legend, a herd of cattle visited the circulating water pit for a drink, floundered through it, and left the water so muddy that it has been used that way ever since.

There are those who say a debt is due to the maritime industry for the early design of oil rigs, because oilfield hoists, masts, catheads, and cables resemble the equipment used by seafaring men, some of whom came ashore to drill the earliest wells. The Spindletop well was only a little more than 1000 ft deep, and was drilled with a 25-h.p. steam engine. Today, although the average depth of oil wells is less than 5000 ft, the deepest producer has recently been completed at nearly 18,000 ft, other wells have gone deeper—two past 20,000 ft, one reaching 21,482 ft (nearly 5 miles deep). Moreover, some rigs are equipped with engines capable of delivering 2000 to 3000 h.p.

* The National Supply Company.

RIG COMPOSITION

A discussion of the units which comprise today's drilling rig must necessarily touch on the several kinds of calculations which go into the planning and design of the complete assembly. Consideration must be given to structural strengths, hydraulic capacities, pneumatic requirements, electrical loads, horse-power demands, and other related factors. The majority of recent drilling rigs are powered with internal combustion engines, although there are a few using electricity and quite a number operating on steam. This paper is limited to the consideration of present-day deisel- and gas-engine-driven outfits. Manufacturers produce these rigs in a range of sizes varying with nominal input of from 100 to 2000 h.p. On the practical rating of 10 h.p/100 ft depth, these rigs are capable of drilling average wells from 1000 to 20,000 ft deep.

Consider a rig which has a nominal rating of 15,000 ft. It is first necessary to ascertain the structural requirements, and, since strings of casing are the heaviest loads to be lifted, 15,000 ft of 7-inch could weigh as much as 500,000 lb or 250 short tons. 5-inch outside diameter drill pipe, with its several hundred feet of drill collars, may weigh up to 150 tons.

WIRE ROPE

The slender but powerful cord which suspends these loads is the wire rope, which may be strung over the derrick in reaving of 8, 10, or 12 lines (usually 8 for handling the drill pipe). For the heaviest loads, $1\frac{1}{2}$-inch diameter is now used, with independent wire rope centre to provide the greatest strength, and to withstand the crushing action which may occur as the line goes through the grooves in the sheaves and around the drum. Factors of safety in wire rope are in the region of 4 : 1 or 5 : 1 for drill pipe and 2 : 1 or 3 : 1 for casing loads. In this 15,000-ft rig, a $1\frac{3}{8}$-inch rope, with breaking strength of about 84 tons, may be used. This will support the drill pipe at 19,000 lb load per line, with 8 lines, and the casing at 50,000 lb per line with 10 lines or 42,000 lb per line with 12 lines. Casing lines are frequently 3500 ft in length, of which about 1500 ft are in service. The balance is on a storage drum, from which a few feet are fed through and cut off at the live end at given periods, or after each round trip, in order to avoid concentrated wear in any one spot. Worn lines are often replaced just before the setting of heavy strings of casing.

DERRICKS AND MASTS

It is possible that the word *derrick* will soon change to *mast*, because derricks are being replaced by the more easily moved, and more quickly erected, masts. Modern derricks are sometimes as high as 189 ft, in order to provide vertical clearance for hoisting the drill pipe in fourbles, or four joints totalling about 120 ft per stand, and the load range could be as high as 750 tons. The popular masts for the larger rigs are 142 ft high, and allow the drill pipe to be handled in thribbles, or three joints of about 90 ft per stand, and the load rating is about 400 tons. These have steel substructures which support the drilling floor, 8 to 20 ft above the ground, to provide space for well-head and blow-out-prevention equipment. The smaller mast for the lighter wheel-mounted rig is usually about 94 ft high, allowing the drill pipe to be pulled in doubles, and has a rated capacity of about 300 tons. For general conditions, these masts do not need to be guyed. Masts for shallower wells are also available in two-legged tubular construction in heights ranging up to 90 ft and of telescoping design (Fig 1).

FIG 1

THE TYPE OF MAST WHICH IS REPLACING THE DERRICK

DRAWWORKS

The drawworks or hoist is the unit which takes power from the engines, and transmits this energy through the wire rope, over the crown sheave, to the block and tackle assembly which raises and lowers the drill pipe and casing in the well. The drawworks is a highly engineered and very compact package which includes a transmission assembly. It is usually made up of four principal shafts on which are mounted a reversing mechanism, clutches, sprockets, and chains which provide three selective speeds to the sand or coring reel and rotary table and six speeds to the main hoisting drum (Fig 2).

The catshaft carries the sand reel, if one is used. Extending out on each end are the catheads. These provide the power for lifting derrick tools and small objects, by means of the catline, and for the make-up and break-out of tool joints and other threaded connexions in the drilling string and casing.

The hoist may contain only one large drum which is used for spooling the casing line, or it may have a second drum or sand and coring reel on which the sand line is wound. The diameters and lengths of these drums are as great as possible, consistent with

economical and portable design, in order that the wire lines may have the most favourable operating conditions. For example, most main drums are now

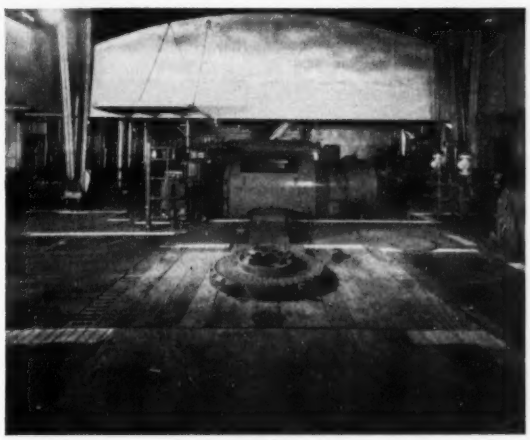

FIG 2

A LARGE DRAWWORKS AND ROTARY TABLE AS MOUNTED ON A DRILLING BARGE

spiral grooved to the size of new rope, and are designed so that the line does not pile up beyond three layers.

BRAKES

These drums are each equipped with dual band brakes which provide nearly 360° contact, and are extremely effective for oilfield service. They provide close control of very heavy loads with only moderate pressure on brake levers, and release quickly when drum rotation is reversed. The brakes on the main drum must be capable of absorbing energy at a very high rate, and for this reason water cooling is employed in the brake rims.

In addition to the built-in brakes, a drawworks also includes an auxiliary brake, attached to the main drum shaft through a clutch assembly. This brake absorbs shock loads and dissipates a substantial amount of the power generated by the falling drill pipe, thereby adding to the safety of the operation and increasing the service life of the band brakes. Auxiliary brakes are generally of two types—hydraulic or electric. The hydraulic brake depends on fluid friction resistance, and consists primarily of a rotor and stator which divert and retard the flow of water, and thereby dissipate the energy transmitted from the drum shaft.

One of the latest additions to a modern drawworks is the use of an over-running clutch in connexion with an hydraulic brake to provide instant release of the brake when drum rotation is reversed, and automatic engagement of the brake when the pipe is being lowered. This free-wheeling feature speeds the raising of the empty blocks and protects the drum shaft and brake against damage from impact loading while the drill pipe is being lowered.

The electric auxiliary brake is a more recent development which accomplishes its purpose by dissipating the energy transmitted from the drum shaft through electro-magnetic resistance. Both electric and hydraulic brakes require water cooling systems.

CLUTCHES

Radially contracting air-cooled clutches, with tyre-like pneumatic elements which expand with the introduction of air to engage friction shoes against a drum, find application where the clutch operates disengaged for long intervals, as there is no moving contact between driving and driven elements when the clutch is idle. Multiple-plate clutches are also used, especially where there is very heavy torque loading, as on certain drum shaft applications. Air is used to actuate most of the clutches and other controls on today's drawworks.

The control cabinet or console usually includes twenty to twenty-five levers and pedals for clutch operation, speed changes, engine throttles, and so on. In addition, there are about ten gauges and indicators for the driller's convenience, so he can see at a glance whether or not air, oil, and water supplies and other operating conditions are adequate. Lubrication of the drawworks is usually accomplished by pressure grease connexions to bearings, and liquid spray outlets for chains and sprockets (Fig 3).

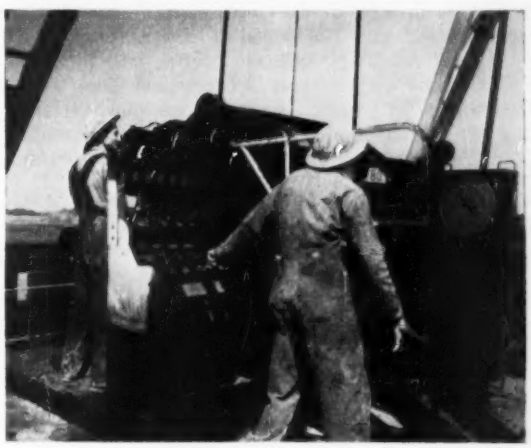

FIG 3

A DRILLER OPERATING THE BRAKE WITH HIS RIGHT HAND AND THE CONTROLS WITH HIS LEFT HAND

OTHER ACCESSORIES

A very important accessory for a rotary drilling rig is the weight indicator. This device measures the live pull on the casing line at the dead end anchor, the reading is produced on an instrument directly in

front of the driller, and it is possible to determine almost at a glance the weight on the bit, the load suspended in the derrick, or the amount of pull on stuck pipe.

Drilling controls are proving to be very useful additions to drawworks, and are being put on old installations as well as new units. This device automatically controls the rate at which the casing line feeds off from the drum. The control may be set for a constant rate of feed, such as 1 f.p.m., or to maintain uniformity of weight on the bit. As an important safety factor, the device is made to shut off the feed entirely if there is any failure in the control system. Thus the driller may be relieved of the necessity for always standing with his hand on the brake lever in order to control the rate of feed during rotation of the bit. In fact, the smoothness of the drilling operation and the useful life of bits may be substantially improved with employment of the mechanical feed control.

POWER PLANT

The drawworks receives its power from a drive group in which the engines are mounted on heavy structural frames. These provide a chain driven power plant which ties the output of the engines together for hoisting, divides the power for mud circulation, mud mixing, and rotary table operation, or isolates an engine if repairs to it are necessary while the rig is in operation. Clutches to control these various combinations are usually air actuated, and can be operated from the driller's position, or at the slush pumps, or at the engines themselves, as may be required. The chains which connect the drive group are run in oil-bath enclosures, well protected against dust and weather. The power goes to the drawworks by chain. Slush pumps powered from the rig may have V-belt or chain drives, depending on horse-power and other requirements, with chain becoming more popular for this purpose.

ENGINES

Engines may be six-, eight-, or twelve-cylinder, straight or V-type, using gas, diesel, or dual fuel, and running at speeds from 700 to 1800 r.p.m., 900 being very popular. Actual oilfield horse-power output may range from 100 to 700 per engine, and with one to four engines in a drive group there could be 100 to 2800 h.p. per rig (Fig 4), also, there may be other engines installed on independent pump drives for mud circulation and mixing. The 15,000-foot rig may have about 2000 h.p., depending on slush pump requirements. Natural or liquefied petroleum gas are very satisfactory fuels; each operates at moderate compression pressure, and are suitable for engines of comparatively light construction. Diesel engines are usually used in overseas and exploratory work. Dual-fuel engines, using diesel oil for ignition and gas for 50 per cent or more of the fuel mixture, can be run on full diesel if no gas is available, or can conserve fuel oil if there is a gas supply. Supercharging adds substantially to the output capacity of the engines, and is frequently employed on drilling rigs. Good air cleaners, full-flow lubricating oil filters, water temperature controls to keep engines within the correct heat range, and automatic devices to stop the engines in case of lubricating oil or cooling water failure, are all part of a modern power plant.

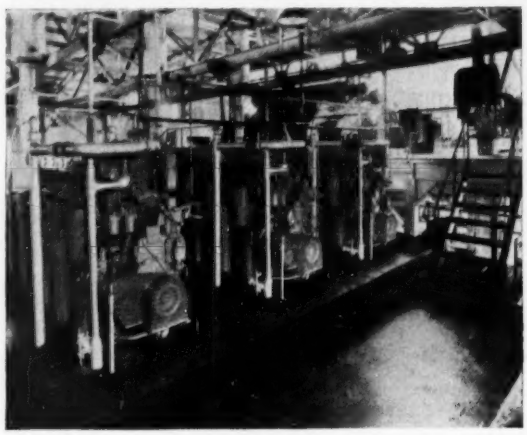

FIG 4

A GROUP OF THREE DIESELS ON ONE DRILLING RIG

POWER TAKE-OFFS

Engine power take-offs may be of three general types: mechanical, fluid coupling, or fluid torque converters. There is also an electrical coupling now in process of development for this use. Each of these has its proper place in engine-driven assemblies. Mechanical disk-type clutches are commonly used to take the power from engines in many kinds of service, and have given a good account of themselves in the oilfield when properly cared for. They provide positive connexion between engine and driven unit when properly engaged, and therefore have greater efficiency than other types of drives in which there is some inherent slip.

Straight fluid couplings, involving no torque multiplication, have come into general use, especially with large heavy-duty engines, because they provide a cushion between engine and driven unit, and prevent shock loads coming back from the hoist, through the transmission, to the engine. These couplings consist basically of two parts, a driving element and a driven element. A self-aligning pilot bearing is the only mechanical contact between the two halves. A vortex of oil circulates between the driving and driven elements and transmits the power of the engine into the drive group. The efficiency of these couplings is in the very high range of 94 to 98 per cent. Such couplings can be provided with scoop controls by means of

which the driller can regulate the amount of fluid in the coupling. As the fluid is withdrawn, the slip of the coupling increases. In this manner it is possible to control the engine power output through an infinite number of steps down to full stall of the driven unit, such as a slush pump, without multiplying the torque output and overpulling against the load. This feature is of inestimable value for precise work, such as fishing, or milling, or holding pressure against the formation. When a fluid coupling in operation is emptied of fluid, it acts as a complete cut-off between engine and rig, and makes unnecessary the use of a mechanical clutch on the engine.

Hydraulic torque converters provide another type of fluid drive which also has the advantage of cushioning the engines against the sudden shock loads which are often unavoidable in a drilling rig. Converters usually consist of three principal parts, impellers, stationary reaction blades, and turbines. The prime characteristic of the converter is its ability to increase the torque or turning effort of the output shaft to as much as five times the input torque from the engine. A converter permits the engine to run at full rated speed, it provides greater starting torque than the engine itself is capable of producing, and it has the equivalent of an infinite number of speed changes. Torque converters are frequently used with high speed engines, and are particularly indicated when engine torque capacity is likely to be less than the rig may require for full load operation.

Cooling facilities must be provided for both fluid couplings and torque converters. This can be done by adding to the radiator capacity of the engine or, preferably, by installing a separate radiator or heat exchanger. The cooling capacity required is usually equal to about 30 per cent of the horse-power output of the engine, so that excess heat can be dissipated during conditions of extreme slip when the heat loss through the fluid drive is greatest.

SLUSH PUMPS

It is estimated that more than 75 per cent of the total horse-power hours needed in drilling are expended in the operation of the slush pumps. This proportion is becoming greater with the use of jet bits, which require substantially greater fluid volume and pressure in order to force the mud through the bit nozzles at high rates, and thereby keep the sharp faces of the bits clean and the cuttings moving to the surface at increased velocity. Accordingly, the trend in slush pump construction has been towards units with greater volumetric capacity and improved ability to withstand higher discharge pressures, both conditions combining to require substantially more horse-power input. These newer pumps have shorter strokes, particularly in comparison with steam pumps, and operate at more revolutions per minute. They also have slower piston speeds, and therefore less piston and liner wear. One operator has reported outstanding success with new heavy-duty power pumps run in excess of 90 strokes per minute, which is nearly twice the normal speed. Energy requirements may be up as high as 1200 h.p. for driving one slush pump.

Some operators prefer to have their two main circulating pumps driven from the rig transmission, while others use one large pump on the rig for circulation and a smaller one for mixing or emergency standby, with a second large circulating pump independently driven by engines not connected to the rig. These engine-driven power pumps can be operated very successfully in parallel, but are seldom run in series, as is done frequently with steam driven pumps. However, with the use of large air cylinders on the discharge of each pump and with fluid coupling drives, the problem of running power pumps in series has been reduced to acceptable practice, resulting in higher and steadier discharge pressures for the reduced volumes of fluid required in deeper small-hole drilling. Chain drives are successfully used for the new large pumps, with two-speed attachments frequently included in order to permit the slowing down of the pumps when lower fluid rates are needed.

MUD SYSTEM

One of the most important accessory assemblies included in a modern rig is the system through which the drilling mud is conducted from the time it leaves the overflow pipe at the well head until it is picked up again by the slush pumps and returned through the drill pipe to the bottom of the hole. Today mud pits are no longer sump holes dug in the ground near the rig, into which the mud flows through earthen ditches. Instead, several steel tanks are used, beginning with a shaker tank, where the cuttings are removed from the mud stream by vibration and settling. Steel ditches conduct the mud from one tank to another. There are complete facilities for mud mixing, chemical treatment, and the addition of coarse materials, such as cotton-seed hulls, redwood fibre, cellophane, and other material sometimes necessary to protect the formation and overcome caving conditions. The primary mixing tank may also be used for preparing the cement for water shut-off and casing setting operations. One of the important advantages of this system of mud tanks is that a good head of fluid can be maintained over the slush pump suction connexions, thus assuring better pump performance.

ROTARY TABLE

On further reference to the derrick or mast floor, consideration must be given to the rotary table. This provides the means for turning the drilling string at speeds up to 350 r.p.m., and thereby imparts the necessary cutting action to the bit. Rotary tables are usually driven from drawworks by means of sprockets and chain or with shaft drive through bevel gears and universal joints. Some operators use rotary tables with independent drives, the engines or electric motors being fixed either on or below the

derrick floor. The power required for the rotary table is less than that for other functions of the rig, such as hoisting or pumping. In a 15,000-ft well it might be estimated that 50 to 350 h.p. would be the range of input energy, depending on speed of rotation and other variables. A modern rotary table includes built-in air operated slips which are capable of safely handling long strings of drill pipe, and which can also be used for the setting of maximum strings of casing in much shorter time than has been possible in the past. Dependable devices are now available for measuring the torque which the rotary table transmits to the kelly, giving the driller a means, besides his own judgment, to measure the effort being put into the turning of the drilling string.

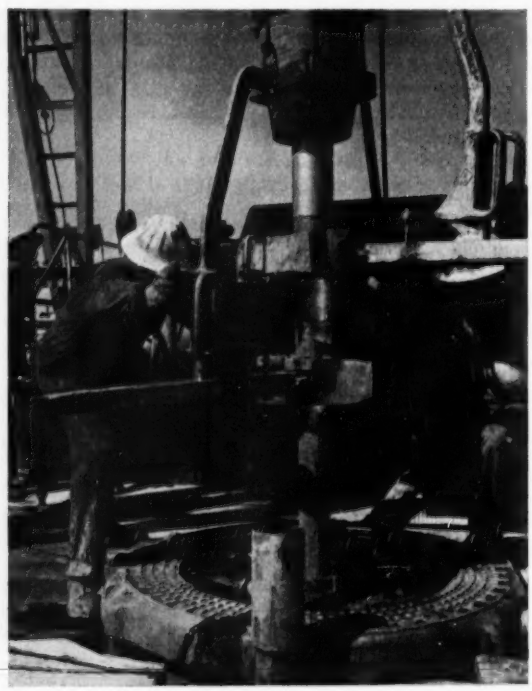

FIG 5
DRILLING IN PROGRESS, THE TONGS HERE BEING HANDLED BY TWO MEN

DERRICK TOOLS

At the top of the mast is the crown block through which the casing line runs from the drawworks drum, and travelling vertically in the mast is the hook-block, which forms the lower part of the block and tackle assembly for raising and lowering the drill pipe and casing in the well. These hook-blocks are recent developments which substantially combine two former pieces of equipment into one, and thereby reduce the length of working tools hanging in the mast, thus giving the driller additional vertical clearance for the hoisting operation. Modern safety features in this new combination include ample guards around the moving sheaves in the block, and safety latches which will not allow the hook to open unless purposely released by the crew (Fig 5).

The swivel is one of the derrick tools performing a variety of operations which make it a very unique device. It must be capable of supporting a load of 250 tons or more at rotating speeds as high as 350 r.p.m., at the same time conducting the drilling mud from the rotary hose down into the kelly and thence into the drilling string at pressures perhaps in excess of 3000 lb. Bearings to take such heavy loads at high turning speeds, and suitable packing to withstand high-pressure drilling mud, have been developed only through years of constant experiment and close attention to operating conditions.

Next under the swivel is the kelly, or drill stem, which is a square or hexagonal steel forging with upset ends, and is used to transmit into the drill pipe the turning motion of the rotary table. Kellys range in length from 30 to 54 ft, depending on the size of drill pipe and other conditions, and are carefully machined to provide true concentric bore and accurate external dimensions. Hexagonal kellys have greater tensile strength and resistance to torsional stresses because the design provides a large cross-sectional area. Thus it is possible to have a larger bore than in the same relative square kelly of older design, thereby permitting the flow of a greater volume of drilling fluid. The steel used in the manufacture of kellys must have the best attainable combination of toughness, tensile strength, and resistance to torsional strains.

DRILL PIPE, TOOL JOINTS, AND DRILL COLLARS

Drill pipe and tool joints have received a great amount of attention from manufacturers as drilling has become progressively deeper. While grade E drill pipe, with minimum yield strength of 75 000 lb, has been quite satisfactory for drilling at 10,000 to 15,000 ft, it has been necessary to develop stronger pipe, with a minimum yield of about 105,000 lb for deeper work. Stronger tool joints have also been produced. These have hard-faced bands to resist abrasion and shrink-thread connexions to the drill pipe which avoid high-stress concentrations, provide pressure seals, and are easy to replace in the field. Plastic coatings have met with success in resisting corrosion in the drilling string. New 5-inch outside diameter drill pipe, internally upset and fitted with internal flush tool joints, is becoming quite popular because it permits increased mud circulation rates with minimum change in pressure.

The present use of more drill collars in the string is effective in keeping the drill pipe in tension while supplying sufficient weight to the bit for the best rate of penetration. Although a drill collar appears to be a fairly simple piece of equipment, just a length of seamless steel with a hole bored through it and

threaded connexions at the ends, the importance of good drill collars in a drilling string cannot be too strongly expressed. Physical characteristics, particularly the ability to resist shock, are paramount, and the quality of steel used in drill collars must be faultless. To all this must be added a careful selection of joint sizes, close attention to torque used in field make-up, and very thoughtful handling both in and out of service.

BITS

All of the equipment mentioned above, is designed, built, purchased, and used for just one purpose—to provide effective power, weight, lubrication, and cleaning for the tool which does the actual cutting or digging of the well—the bit. Bits are available in a variety of specifications to suit the type of drilling and the formation. Blade-type bits are used where the scraping action is sufficient to bore the hole at a satisfactory rate, especially in soft formations. However, most of the bits now in service are of the rolling cutter type. These bits are made with two, three, or four cutters and in a great variety of cutter designs to meet the requirements for penetrating all of the formations encountered in oil-producing areas. Jet nozzles are now being added to roller cutter bits to increase the velocity of the drilling fluid as it is discharged against the face of the bore. The high velocity of the drilling mud forced against the bottom of the hole probably helps to penetrate the formation. However, the prime purpose of the jet streams is to cause such violent turbulence around the face of the bit that the rolling cutters will be washed clean and will do a better job of cutting the formation. Older rigs equipped with small power plants and low-pressure pumps may not be able to impart the necessary force to the fluid in order to take full advantage of this recent development. Diamond-faced bits are also proving very useful, especially for coring, in formations which do not readily yield to roller cutters. When a diamond bit is to be used in a well, it is advisable to first run a magnetic fishing tool to pick up small pieces of steel which might have been left in the hole from other bits, and which could tear the diamond particles out of their retaining matrix.

Sometimes it is desirable to provide a larger diameter hole for a few feet near the bottom of a well in order to have more area for cement or for gravel packing or to expose a greater area of oil sand. This enlargement below the regular hole diameter is accomplished with wall scrapers, having expanding cutters, which are opened to the full cutting gauge by hydraulic pressure after being lowered into the zone to be enlarged. The cutters close again into the scraper body by spring pressure as the tool is being brought to the surface.

BLOW-OUT PREVENTION

During the drilling of the well, it is necessary that protection be provided against high pressure zones which might be encountered. If not controlled, these could cause very substantial damage. Modern blow-out prevention assemblies often include three devices which close against well pressure. These include a cellar control gate installed on top of the casing flange, and equipped with rams which will close the area of the casing, when there are no tools in the hole, much as a valve may be closed to hold pressure in a line. Next there will be installed a second control gate which has rams of the necessary size and shape to close tightly around the drill pipe, which may be in the well at the time, thus confining the well pressure to the annular space between the casing and the drill pipe. The third blow-out preventer, installed just below the mud return line, is designed to close around any of the elements in the drilling string, such as the kelly, drill pipe, tool joints, or drill collars, and also to close and hold tightly if the casing is open. These three blow-out prevention devices are operated hydraulically from a central accumulator which maintains oil under 1500-lb pressure. The control devices for closing the preventers are located in two stations, one on the derrick floor and the other at a safe distance away from the well. From either position it is possible to close one or all of the preventers and thus avoid losing control of the well. The topmost preventer can be released slightly to permit rotation of the drill pipe or to allow it to be pulled out under pressure by stripping over the tool joints while still holding the well under control.

CASING AND ACCESSORIES

Casing has undergone the same evolution and improvement as have been characteristic of all oilfield equipment. For longer, heavier strings there is available grade P-110, which has yield strength of 110,000 p.s.i. and is capable of maximum setting depths of 20,000 ft. Threaded connexions with minimum outside diameter and maximum joint strength are available for those strings which have limited clearance, and require maximum speed during running in the hole.

When a string of casing is to be run in a well, it is usually equipped on the bottom joint with a wash-down whirler float shoe. This tool has a rounded nose which helps to guide the casing past side-wall irregularities. It is equipped with a back-pressure value which closes against the fluid in the well and floats the casing, or makes the string more buoyant, as it is being lowered. Circulating fluid passages are milled in the wall of the shoe and through the centre, so that bridges which may have occurred in the hole can be washed away. When the cementing point is reached the whirling action of the slurry being pumped down through the casing will form a complete and uniform body of cement around the shoe. Next above the shoe it is customary to install wall scratchers which are made up of spring-loaded wires, set in steel bands and fastened around the casing. These wires are pitched upward so they can easily be lowered

into the hole, but when the casing reaches the bottom, and then is lifted up a few feet the wires scratch the mud cake from the wall of the hole and thus insure better contact for the cement. Next on the casing string, centralizers will be installed. These are spring assemblies which fasten around the pipe and hold it in the centre of the bore so that the cement will flow in uniform thickness around the casing, instead of there being possible failure of the cement job if the casing is off centre, thereby causing the cement to channel.

CONCLUSION

All of the advancements in the mechanics of drilling oil wells, however briefly described in the foregoing paragraphs, are the result of countless trials and failures, always surmounted by the ingenuity, ability, and determination of those who build and those who use these highly specialized facilities. There can be no doubt that this unbeatable combination of drilling and manufacturing technologists will continue to find better ways to drill oil wells as time goes by. Meanwhile, every rotary drilling rig stands as a monument to the skill and co-operation of those men who have so developed their respective arts that mankind may continue to live in and enjoy the benefits of the great age of petroleum.

ACKNOWLEDGMENTS

The author wishes to acknowledge with thanks the suggestions and assistance received from J. R. Mahan, Director of Engineering, and other associates in the National Supply Company; L. S. Dawson, managing director, the Oil Well Engineering Company; and various British and American drilling equipment engineers whose advice has been most helpful.

DISCUSSION

W. E. Madden: When speaking of drawworks drums, Mr Reichert mentioned spiral grooving, and I would be interested in his opinion on the special type of grooving which has a kink in it, and which is supposed to give a better turn back for the wire line at each end of the drum. Then, in regard to power take-off, Mr Reichert referred to fluid couplings and torque convertors, and I believe I am right in saying that the efficiency of the torque convertor is probably 10 or 20 per cent lower than that quoted for the fluid couplings. This, of course, means that the prime mover must have higher power in order to get the same effect at the drum, or whatever else it is required to drive. It also means a larger and more expensive prime mover, more waste, and in view of the equal advantages of the torque convertor in increasing torque and providing an infinitely variable gear, it would be interesting to know what the relative popularity of the two types might be.

Anyone who has had anything to do with rigging up a rig for the first time will appreciate that because of all the parts which have to be fitted together, there is usually a whole crew of welders and fitters falling over each other. Recently, however, my company introduced a system which we called "unitizing." This entails fitting the rig together in as few transportable units as possible, so that there is a minimum amount of assembly work before drilling commences. Initially, trial assemblies are made by most manufacturers before such rigs are shipped abroad.

Mr Reichert's remarks about slush pumps, in his paper, reminded me of the conflicting factors which the petroleum engineer had to balance, one against the other. Of course, everybody would like a slush pump with as high a pressure and big a volume as possible. As Mr Reichert mentioned, the high pressure is most desirable for bit nozzle velocity, in order to keep the bit clean. Even in my experience, it is desirable for "hydraulic mining," but admittedly in a very soft shale. The volume in the annulus is, of course, necessary for the minimum upward velocity to carry the cuttings up to the surface, and thereby prevent them from settling back and blocking the pipe. The velocity can also be reduced if the viscosity of the mud is increased, but it is necessary to introduce greater circulating pressures and lesser cleaning action of the bit. Thus the ideal is high volume and high pressure, but these are expensive and require a lot of horsepower—another costly item. Furthermore, both the engines and the pump are very heavy, and extremely difficult to move in swampy country. So the petroleum engineer has to balance costs, pressure, volume, viscosity, and drilling speed to get the minimum cost per foot drilled. He must also devise a mud which has the right weight, viscosity, and plastering properties for the formation he is drilling.

I think we can fairly say that the rotary drilling rig is like Topsy, it just "growed," and a mechanical engineer who goes on to the rig floor for the first time is rather apt to turn pale when he sees that collection of very noisy and rugged prime movers, clutches, chains, drawworks, rotary tables, and goodness knows what, and he cannot quite make out how to do anything. Of course, the fact remains that nobody has yet been able to devise a contraption which will drill a hole in the ground more cheaply and quickly than the modern rotary drilling rig.

An idea was put forward, however, by Mr Hersch a year or so ago, in an address he gave to a gathering of oil people, that surely it is fundamentally unsound practice to apply power at the surface of the ground, anything up to four or five miles away, from where you want it, *i.e.* at the bit at the bottom of the hole. We hear all sorts of rumours of electric motors and turbines operating down the hole, thumper-bumper bits, and so forth, but so far they have not really "rung the bell," and I thought it would be very interesting if Mr Reichert could, within the limits of commercial discretion, give us his opinion as to which way the technique of rotary drilling might go in future.

C. T. Reichert: Mr Madden has brought up some very interesting points.

First, about spiral grooving, the popularity has been up and down, and now up again. Several years ago, spiral grooving was turned on new drums, but it did not take on at all; it was neither popular nor long before the grooved drums were turned smooth again. Possibly, at that time, the chief reason was that spiral grooving would accommodate only one size of the wire rope, and so plain drums remained very popular for a long time. Then the industry began to realize that the cost of wire rope replacements was one of the expensive items of running a rig, and began wondering what could be done to economize. Eventually it returned to the spiral grooving. Beyond any doubt it does give the wire rope proper support, and prevents quite a bit of friction of the

line rubbing against itself, and otherwise does a better job of getting the most out of a piece of wire rope. Thus, today, most rigs have grooved drums, unless the operator is determined that he wants to be able to use either 1- or 1¼-inch, or 1⅜- or 1⅝-inch, line, whenever he pleases. Although interchangeability of line size is lost, the service of the line is so much better that spiral grooving is beyond any doubt the proper practice, and it is a pleasure to see it is now coming into its own.

As to the type of grooving, I think this is a debatable matter which involves some sales talk. Competent engineers can lay out a suitable design for grooving drums, and the proper turnback at the end of the drum will see that the line comes back again on the next layer without jumping. Beyond that, I have no comment on any special device. There are many other things besides the grooving which affect the life and the spooling of the line. These are the rubber bumpers, centralizers, and other devices which are sometimes used to steady the lines; so the matter of how the grooving is done, or what little trick or wrinkle is included in it, is often beside the point. The grooving must be well done, properly engineered for size of the line, and, beyond that, so long as the drum is grooved, it will reduce the cost of operation.

Now, the subject of torque convertors versus fluid couplings is one to which an entire meeting could be devoted. It is not exactly a controversial point, it is the problem of appreciation and compromise which occurs in all machinery selections. There are installations where torque convertors should be used beyond any question. There are also installations where the fluid coupling is much better. It has been interesting to see over here in England that torque convertors generally have not become popular, although fluid couplings for various kinds of industry have very well held their own. Perhaps a guide in this selection might be that where there is enough engine horsepower and torque capacity in the engines themselves, the fluid coupling is better, because it provides cushioning, it gives very much higher efficiency, probably 95 to 97 per cent, and it is a very durable item which lasts a long time without repairing. On the other hand, if the horsepower is insufficient for the work to be done, if the engines do not have the ability to really take over the load, then the torque convertor will come in, and although at a very much slower speed, it will move the load. If it happens to be pipe stuck in the hole, or a slush pump that is up against very high pressure, the torque convertor will let the drum or the pump move slowly, but nevertheless move without stalling the engine. The use of torque convertors in the U.S.A. on drilling rigs as compared with fluid couplings is a guess on my part. In numerous rigs, torque convertors are probably more popular, especially in the smaller rigs, but on the 10,000-ft and deeper rigs, I would estimate that fluid couplings are by far in the majority. Again, if an operator has to have a heavy rig and can pay the price for it, he will buy engines which are big enough to handle the loads, and the fluid coupling then comes in as a cushioning, cut-off, and speed-reducing device when the fluid is drawn off, thus allowing the engine to maintain its speed and thereby accomplish its work. If, on the other hand, it is a small rig, it must be more compact, there cannot be numerous engines, and the extra urge is needed to start the load moving, then the torque convertor is good. One of the problems with torque convertors is that, because of their ability to multiply the turning effort, drillers are inclined to leave the hoist in high gear much longer than they should. The result is that the chain and bearing, which are built to run at definite speeds and under given loads, are punished more than they should be, and the repairs are likely to be high. A torque convertor works best at its highest efficiency, say somewhere around 75 to 80 per cent, when the multiplication is not over 2 : 1, and yet you will see drilling crews pulling the loads fair on down to where the torque convertor may be almost at its maximum multiplication, and that is the time when the rig is really taking a beating. Now it is one of the projects of the industry to get the drillers to understand that they must shift to a lower speed in the transmission, instead of depending on the torque convertor to do the whole job.

If torque convertors and fluid couplings are subjects which members would like to discuss sometime, I would be glad to forward a nice assortment of, shall I say, competitive information, and someone could make a very interesting paper out of it.

As far as rigging up is concerned, it is becoming very popular to have rigs assembled before they are sent to the field. Of course, many are so small that they are practically rigged up, except for connecting the pumps, before they come off the manufacturing line. Among the big rigs that I know of that have been assembled before they were shipped, one went to Kuwait, one to Trinidad, one to Australia, three to Columbia, one to Peru, one to Venezuela, one to Sicily, one to West Africa (that has not landed yet), and another to Nigeria. It is generally recognized, especially on these outpost jobs, that if we can get the rigging up done where supplies are handy and manpower is available, and where there are cranes and hoists and other facilities, it can be done for less money and for very much less time than in the field.

The thing that the operator sacrifices is the drilling superintendent's personal idea of how a rig should be put together. He does not always get all the piping where he thinks it ought to be. I do not mean to say that rigging up is not always done to order, but the engineer who may rig up the job probably does not quite satisfy the drilling superintendent who finally gets it. However, strangely enough, the rigs run all right even if the pipe goes around the left side instead of the right, and vice versa.

As far as slush pumps and bits are concerned, Mr Madden is exactly right. There is always the question of whether one should have a big pump or jet bits. The answer to these problems is the same as the answer to the selection of any machinery. The engineer's choice involves competing factors, such as price, weight, and various other things.

Portability is a tremendous problem in the oil industry. Whether one shall use big pumps and pour the fluid in the hole, perhaps to get to the well bottom quickly, is a thing that is up to the individual economy of the project, and I am sure that there is not any fixed rule by which the problem can be solved. Rigs are needed to do the job in the quickest time or to yield the best return. We must drill wells for profit, besides for the pleasure of saying that we can ride in automobiles and not have to go back to horse-drawn carts.

As for future trends, Mr Madden realizes, probably more than most of the men here, that machinery for the oil industry can be developed only with the help of the oil men themselves. I do not know of any manufacturer who uses the oilfield machinery that he makes. The result is that the manufacturer goes to the operator and tries to find out what the operator needs. Then if there are enough operators needing the same thing, production of the new unit can be established on an economical basis. In Mr Hersch's paper there was an item about having the rotary table with the air-operated slips built integral with the table. His paper was delivered a year ago, and we now have exactly such a rotary table with the slips built into it. That is only one example of how the manufacturer tries to build what the operator wants.

In regard to electric power down in the hole, I am sorry to have to plead ignorance on the subject, except for some hearsay which is not very complete.

As regards this thumper bumper which Mr Madden

referred to, I know of a rubber drill collar which was built, because the thumping and bumping was too much and it was necessary to cushion the vibration. But the test was never completed.

There is no doubt that there will be changes in the design of equipment. It is well known that gas is being used as a circulating medium, instead of mud, in some areas. This accomplishes a purpose which cannot be attained with mud. Principally, though I am not too well informed on this, it has to do with lost fluid circulation, but it has the disadvantage of being very hazardous.

R. M. Smart: I would like to raise the question of electric drilling. One arrangement is to have constant speed engine-driven generators supplying D.C. motors. The installation is simple and readily portable.

The all-electric system using an incoming supply from overhead lines, such as at Ventura, is an alternative—but does Mr Reichert think that there is a future for a D.C. motor on these drives?

One cause for concern is the stalling of the motors and pumps. Is this a condition of operation, and is it necessary to cater for such a condition when using electric motors on the rig drives?

C. T. Reichert: There are a few electrically-driven rigs in operation. They have been used on and off for many years. The problem with electric rigs seems to be first cost and operating cost. Because of the necessity for having a generating plant attached to the rig, there is an efficiency loss, maybe as heavy as 20–25 per cent, plus the high cost, plus the necessity for having specially trained staff. Generally, it has been found that the more direct connexion of engine to fluid coupling to drawworks and pumps is very satisfactory. It appears that fluid drives, either with straight couplings or torque convertors, particularly the couplings, have come strongly into service and perhaps may have interfered with the use of electricity. Fluid couplings have a very high efficiency, and they let the engines run at favourable speeds. It would appear that, without a dampener such as a fluid coupling (there is now also an electric coupling to do similar work), electric motors might have had more popularity. My own experience of electricity lately has been very interesting. Just before I left Los Angeles my firm assembled an electric rig for use on a moving picture property. It was in an acreage which the picture company had been using for recent pictures and also where there are many residences in the immediate area, so the rig had to be quiet. There were to be no noisy Diesel engines or gas engines or anything like that, so it was necessary to use electric motors. We had to go back to an old rig to find a drive group which had electric motors which could be used immediately. The motors received current from the nearby power line, which is about 15,000 volts cut down to 440. I think there are five motors in that job: three on the drawworks (much like engines in line), and two on the pump. The derrick is swathed in sound-deadening material, so the installation certainly runs quietly.

At present the industry is not generally in favour of electric drives, except perhaps on locations such as that described above.

In so far as the stalling of the pumps is concerned, there must be protection for that emergency. Both pumps and drawworks may stall, either accidentally or purposely, and it is therefore necessary to provide some slippage. Fluid couplings may be used for electric motors, and these should give adequate protection, similar to that achieved with other direct-connected engines in industry.

P. H. Crumley: I wonder if Mr Reichert could tell us anything about the possibilities and difficulties of offshore drilling?

C. T. Reichert: I regret I can only tell you a little about it, because my courses of duty have not yet involved very much offshore drilling. I presume Mr Crumley means drilling where the rigs are generally located in water, and in this respect my experience is limited to rigs located on piers. First I may mention that some excellent pictures have been made in the U.S.A. on offshore drilling.

In my territory, California, the slant hole has been developed as a form of offshore drilling. At Huntington Beach there is a strip along the shore line, perhaps one mile wide, in which wells are located on the surface, about 20 ft apart. All those wells are inclined under the Pacific Ocean—some as much as a mile, and at angles up to 60°, which on paper looks almost horizontal. Strangely enough, only a very few of this large number of wells, which have been so directionally drilled out into the oil-producing formation under the water, have interfered with others. This is certainly a compliment to those men who are able to control directionally the drilling of wells. Most of the Gulf work, as I understand it, and this is only hearsay, is in fairly shallow water, *i.e.* up to 50 or 60 ft, most of it less than that, which is not too much of a problem. The Gulf is fairly well protected, although storms do give the workers a reasonable amount of trouble. Drilling barges and islands are both being used, including the six-well development. Seismograph work evidently indicates that offshore drilling from California may be successful. The trouble is that the shore line drops very quickly, and within the course of about 100 to 200 ft from the shore, the depth extends to about 200 ft. At the 200-ft level under the ocean, the ground is firm and could support a structure, and some work has been done in planning such a structure. It amounts to a steel framework for a twenty-storey office building, which would be a tremendous undertaking to get out to sea and located properly, and then to put equipment on top. There has also been talk of filling in the 200 ft with earth, but that is also considered an enormous project.

R. K. Dickie: I would like to say a few words about electrification of rigs. During the second world war, when we were developing a field at Eakring, four National 50's were brought over from the U.S.A. Each of these were intended to be driven by two Waukesha semi-diesels. The ship carrying some of the engines was sunk, with the result that there were only enough engines to supply three rigs with power. Previously most of the drilling had been done in this field by rotary rigs designed about 1930, and some of these were powered by electric motors, as electric power was available in the field. These motors were specially manufactured for the job, and were flame-proof, 200 h.p., A.C., and could be controlled down to about half maximum speed. The fourth National 50 was equipped with two of these motors mounted in place of the Waukeshas, and they proved to be quite successful. Indeed, it was found that by using the friction clutches on the gears on the rig it was quite unnecessary to control the speed of the motors, which ran continuously, except for one shut down of a few minutes each day for a routine check over. As far as maintenance was concerned they gave far less trouble than the diesels. They were well liked by the drillers after some early scepticism, although, as far as I know, they had never handled electric equipment before. This drive is still used in operations where electric power is readily available. It is unfortunate that in most places where drilling is carried out power is not readily available. Otherwise electricity would no doubt be universally used.

C. T. Reichert: I am sure that what you say is true. There is a place, and I hope I did not give a contrary impression, for electric drilling. As a matter of fact electricity more nearly approaches the flexibility of

steam than does the internal combustion engine. It has only been with the advent of fluid couplings that the use of internal combustion engines has become satisfactory. I think, however, that the problem of generating an adequate supply of cheap electricity is the most difficult one to solve satisfactorily. Of course, in some areas gas is available, and this is usually much cheaper as a fuel when gas engines are also available.

R. H. W. Hamilton: I wonder if Mr Reichert could give us his views as to the relative use in the world today of derricks versus masts. In the old days all wells were drilled with derricks, but masts have gradually come in, and, I think, have largely superseded them. It would be interesting if Mr Reichert could give us his views as to whether they are going to be completely superseded, or what their future will be.

C. T. Reichert: I think that masts will come into increasing use from now on, with the exception of a few situations which probably require derricks. The change has been brought about in this way: masts cost about $50,000 (£17,000) each, and this sum is certainly much less than that for a derrick. But now that so many wells are being drilled by contractors, instead of oil companies, the very high extra cost of the mast can be offset by contractors after drilling about six wells. A mast, of course, may be used for many more than six wells. Drilling contractors make money by their ability to "punch" holes successfully and quickly, move on to the next job, and at the same time satisfy their clients, the oil companies. The derrick is not left standing over a well which should be producing for the week or ten days that it takes to get it down and moved away. Also there does not have to be the advance planning to move a derrick in and have it erected and then be left standing idle for two or three months until the rig moves in. In the contractors' side of the business, I am sure the masts are here to stay, and I expect that the same thing will apply to the oil company rigs also.

Another problem is that crews for erecting derricks (derrickmen) are becoming almost extinct. I know of only one good crew in my territory, where there used to be dozens of rig builders who could put up either wooden derricks or steel derricks. Today, if you want to take down a steel derrick it is a bit of a problem to find men who can do it, so this is another factor which has contributed to the changing practice.

H. R. Lovely: Mr Reichert has mentioned the use of jet bits and the need to improve pump capacity, which involves higher pressures and volumes, and also higher costs and weights, but I believe there is a tendency to use larger size drill pipe in the U.S.A. in order to improve the hydraulics of the drilling system, and thus obtain better service from jet bits without necessarily increasing the pump size. I wonder if Mr Reichert could comment on this tendency and give us any idea as to the effect of an increase in drill pipe sizes in promoting better hydraulic efficiency and obviating, to some extent, the need for bigger and more expensive pumps.

C. T. Reichert: The trend towards 5-inch drill pipes, instead of 4½-inch, may not be very much of an increase in diameter, but it is very much of a help towards greater circulation. It also lowers the pressure considerably—much more than would be indicated by the small change in size, and thereby it enables the existent slush pumps to do a better job of pushing the mud through. Thus, the large diameter drill pipe with its drill collars, tool joints, and so on has undoubtedly come to stay. Certainly, every attempt is being made to have the fluid passage just as large as possible. This is a big help, which means also that it is possible sometimes to run jet bits, even with smaller, older pumps. That change also is likely to be permanent.

A. J. Parker: Could Mr Reichert tell us how API standards for drill pipes and tool joints are used in the American field. Do they use them, or do they use their own standards?

C. T. Reichert: I regret I can not answer that question as I should like to. I can guess, and probably you will agree, that the deeper drilling and the larger fluid areas and various other field changes have caused the industry to get somewhat away from API standards on tool joints. I do not think this is any reflection on the API standards, which follow along the industry's development. The API does not necessarily lead in standards, but often has to wait until operators have established their practice. It then tries to consolidate and bring the practice into line with good workmanship and materials.

H. C. Lack: There is one piece of equipment which Mr Reichert has not mentioned, and that is the rotary hose. What are the latest developments in this direction? Will hoses continue to be rubberized, or will metallic hoses take their place?

C. T. Reichert: The use of steel versus rubber rotary hoses is, to some extent, a matter of personal preference. One can be reasonably satisfied that steel hoses are more capable of being able to hold high pressures. Moreover, they are not damaged as easily as rubber hoses. One of the chief difficulties with rubber hoses is the maltreatment they get in the field. Rubber hose failure is seldom explainable unless one has had the good fortune to watch the hose being moved or laid on the derrick floor. For it is at such times that the rotary table, or other things of that kind, may be dropped on it. Modern manufacturing practice has reached the point where very good rubber hoses can be, and are, made to stand the high pressures required for jet bits. They are also easier to handle than steel hoses, but are subject to more damage.

E. C. Masterson: It is now my duty to express the thanks of the Institute to Mr Reichert for his interesting paper. Mr Reichert is in London at the present time on a special assignment from the U.S.A. I can speak from personal knowledge when I say that he has been a very busy man since his arrival here. I am sure that we all appreciate how much work and thought Mr Reichert must have put into the preparation of his address tonight. When I asked him some months ago if he would be willing to prepare a paper on rotary drilling rigs, he immediately agreed, and I wish to take this opportunity of thanking him personally. I know, however, that everyone present will wish to express their thanks, and when doing this in the customary way I hope you will remember your colleagues who have had to leave before the end of this meeting, and therefore express not only your own thanks but also theirs.

THE INSTITUTE OF PETROLEUM

An Ordinary General Meeting of the Institute of Petroleum was held at 26 Portland Place, London, W.1, on 19 May 1954, the Chair being taken by the President, Lt.-Col. S. J. M. Auld.

The General Secretary read the minutes of the previous meeting, which were confirmed and signed as a correct record. He then read the list of members elected since the previous meeting, and made various announcements.

The President, introducing the speakers of the paper to be presented, said : The meeting this evening is, I think, breaking fresh ground. As far as I am aware, although I am open to correction, this is the first time that we shall have been addressed by a member of the medical profession, and when we find that we are going to be addressed by two, I feel the pleasure will be doubled.

The whole matter of the medical services in relationship to petroleum is one which is very close to us, and although the attendance is rather moré sparse than I would have wished on an occasion like this, I think that we are pretty well a hand-picked selection of those who can take a direct interest in the papers. The first, by Dr McClean, will not be given in person, as he is at present in Teheran, and Mr A. C. Turner will be speaking on his behalf. For the second we have the good fortune to have Dr F. L. Webster of the Shell Company, who is talking about a different part of the world.

The following papers were then presented.

MEDICAL SERVICES IN THE OIL INDUSTRY

By S. D. McCLEAN,* M.R.C.P.

The author's experience of medical services in the petroleum industry is necessarily confined to the activities of the Anglo-Iranian Oil Co. Ltd., but it has been his privilege, however, to have been able to visit several other petroleum organizations, both in the Middle East and in the West Indies.

In general principles, the necessity for, and the organization and operation of, medical and public health service are comparable in the petroleum industry in all parts of the world. In the responsibilities, however, with which the author is concerned, these are divided into those concerning the U.K. and those abroad.

In the U.K. the medical service of an industry forms no part of the National Health Service, and is entirely supplementary to it.

The National Health Service does not cater for the special needs of industry, although every person is entitled to and does receive treatment as and when necessary.

What, then, are the special medical requirements of industry, and what are the duties of the medical officer ? They consist of :

(i) General organization and provision of staff, equipment, and first-aid facilities in relation to the industry and its various branches.

(ii) The setting up of standards of physical and mental fitness for employees for service both at home and abroad.

(iii) Consultation with management in respect of invaliding, pensioning, assessment of disability, etc.

(iv) Liaison with general practitioners who, under agreement, carry out medical examinations on behalf of the Company for specified fees, and the assistance of employees and their families who are resident within his area in all medical matters, such as hospitalization, specialist consultation, etc.

(v) Arrangement of supplies for first-aid units.

(vi) Maintenance of close liaison with research workers in respect of potential and actual health hazards which might arise in the various processes of the industry.

(vii) Liaison with the safety engineers in the prevention of accidents, injuries, and health hazards.

(viii) Liaison with medical officers of health and medical inspectors of factories.

The Company's medical officer is often called upon to advise management when special expenditure is sought to modify the machinery of a particular process unit, so as to remove what might be a public nuisance or potential health hazard to the workers and also to residents in surrounding dwellings. Justification for such expenditure must be given in detail.

The medical officer's advice is sought by management on problems of wide diversity affecting the Company's administration and operation.

Frequently, also, the medical officer is consulted regarding a given individual's fitness to carry out special duties when in other respects he might be chosen because of his technical ability.

Practically every individual has his, or her, problems

* Anglo-Iranian Oil Co. Ltd.

which affect their lives and work in some degree. When this problem is one of health the individual should, and does, consult his general practitioner. Cases arise, however, when the busy practitioner asks for assistance regarding specialist consultation or admission to hospital for an employee. On occasions it is the medical officer's privilege to assist.

Personal problems not necessarily concerned with an illness, nevertheless frequently affect the general health and working efficiency of an employee. The diversity of these problems is as wide as the course of human nature and conflict. Assistance given to an individual who is in trouble is very time-consuming, but it is never a waste of time.

The industrial medical officer's greatest assets are the confidence of management and employees alike, as well as the friendship and respect which are shown to him by everyone.

It is essential that the medical staff at home should be in a position to travel freely to all areas of operations. It is very desirable that they should have lived in some of these places, and have intimate knowledge of the climatic conditions, of the local people, and of the general attitude of staff who must spend so much of their life in foreign countries.

The home medical officer's duties on behalf of the overseas medical service are indeed manifold.

A very close and personal contact has to be maintained with the medical staff overseas. Detailed confidential medical reports are passed direct between them. Special medical codes are used for telegrams. In the event of medical repatriation of a sick employee, arrangements must be made for his reception, treatment, and disposal. This often entails visits to the airports with an ambulance to receive the case and to ensure his rapid clearance by port health and customs authorities, whose co-operation at all times and under varying conditions has been excellent.

Treatment entails making arrangements for the patient's admission to a suitable hospital for attention by an appropriate specialist in London or nearer his home, or alternatively, referring him to his practitioner or to the company's medical representative near his home for treatment, if his case is not immediately urgent.

The medical officer must have experience and knowledge of administration of a comprehensive medical service, of planning for the present and future, of architecture in order to plan, in co-operation with the architects, suitable buildings for special purposes, and large hospitals.

He must have some rudiments of engineering knowledge in order to specify such items as air-conditioning, electrical requirements, steam and water supply, laundry capacity, and various types of special fittings. All furniture and equipment and instruments require selection and specification. One of the biggest difficulties is to know what material should be specified for floor surfaces in halls, corridors, wards, operating theatres, etc.

The supply of drugs, dressings, and materials of all kinds must also be maintained. All this, together with provision of staff, necessitates a knowledge of forward programmes of development in all areas.

The administrative doctor is called upon also to justify expenditure, and to do so he should maintain close co-operation with the accountants.

In addition, his knowledge of his own profession must be wide but not necessarily too specialized.

There are many duties in connexion with shipping. In the Anglo-Iranian Oil Company medical examinations are carried out on behalf of the British Tanker Co. Advice is sought about sick personnel who are under treatment at home and at the many ports abroad where the ships call with their cargoes. In many ways, and on the same basis as for A.I.O.C., assistance is given both to management of B.T.C. and to their staff.

This short description by no means covers the full part played by a medical officer in the oil industry.

MEDICAL EXAMINATIONS

It is probable that insurance companies were first in the field to assess the physical fitness of individuals by medical examination, and from experience gained, they were able to calculate by mathematical formulae the risks on life and endowment insurance policies.

As recently as the beginning of the twentieth century, medical examination for employment in the Civil Service and in industry in the U.K. was not a usual procedure. It was not very general for service abroad, nor was it general for service in military forces.

The advent of the first world war brought a marked change. Medical examination became general for the forces and for commercial employees destined to serve abroad. By slow degrees medical examination became more general for service in the U.K., and since the end of the second world war this requirement has been extended virtually to all organizations.

It is, of course, good policy that management should demand a high standard of physical fitness for new employees. But no standard can be rigidly adhered to; life and the human frame are too variable for that, and it is frequent for the doctor to stretch a point and agree to a particular candidate's engagement, while explaining the potential risks and classifying his health in accordance with a category system.

THE OBJECT OF MEDICAL EXAMINATIONS

A medical examination is an assessment of an individual's physical and mental fitness for employment.

It is essential that the medical officer performing the examination should have a wide knowledge, not only of his own profession, but of the conditions under which the individual he examines will be working. This in itself requires a detailed study of all the varieties of work; of ventilation, heating, lighting. potential hazards from machinery, chemicals and gases

of a toxic nature, etc. Special physical requirements are necessary for particular forms of employment.

Colour blindness is more common than is generally known. The drivers of trains, deck officers of ships, and all persons whose work might involve the clear distinction of colours must be examined for colour vision.

It is found that certain forms of employment require quite different standards of physical fitness from the normal, and therefore a close liaison between medical officer and management is a further essential.

OVERSEAS MEDICAL SERVICE

All British oil companies obtain their main source of oil supply from fields in overseas countries, so in addition to the home offices, research stations, refineries, distributing organizations, and tanker fleets, medical services are required to cater for survey and exploration parties and wildcat drilling teams, and, where necessary, for established production areas and refineries when such facilities do not exist or are inadequate for the purpose required.

In such cases, the overseas medical service must be complete and comprehensive, and must include every aspect of medical requirement. Provision must be made for every emergency, more especially when there is no other authority or organization near at hand from which advice and assistance can be sought or to which cases might be referred.

The building up of such a service is a slow and difficult process, and includes all the paraphernalia of hospital organization and equipment.

Virtually all the professional and technical staff are specialists, so that the acquisition of a team of men and women young enough to withstand the rigours of climate, the pressure of work, and who possess the will, determination, and the desire to live and work under such conditions, and who also have the necessary experience and qualifications for their duties, is a long term process.

When all this is achieved the service must be maintained, but replacement of casualties at short notice is particularly difficult.

Adequate supplies of a wide variety of drugs and dressings necessitates indenting on a large scale with an estimate of consumption of twelve to eighteen months in advance. Doctors are notoriously individualistic. They must be given the tools to do their job. Large stocks of essential supplies must be maintained to serve emergencies such as epidemics. The possibility of being caught unprepared must always be avoided.

Medical administration overseas provides in addition to the purely administrative requirements of the medical service, essential information for general management.

The value of medical records of individual cases both out-patient and in-patient is important for the patient, the doctor, and the management. The responsibility for this is partly the doctor's and partly the medical administrative officer's. The records department must be efficiently organized and operated.

After a number of years, the records pile up—they are invaluable in treating a case, and in assessing the health and value of a worker for compensation, if any, on invaliding or retirement.

Medical Boards are held as required, and cases are examined so that any disability may be assessed in terms of a percentage of the man's working capacity. In the presence of a welfare officer, the worker is given an opportunity to state his full claims.

Hospital administration requires the provision of all the necessary ancillary services in addition to the actual wards for the patients. In a mixed community with different sexes, races, and creeds, separate wards have to be provided. The hospital kitchens provide food, not only for the normal and special diets of different medical needs, but also to suit the various requirements of the different peoples. A catering supervisor controls the daily fresh supplies and stores.

Operating theatres are provided for major surgical and fracture cases, and for minor surgery. Adequate staffing and the provision of suitable equipment must be maintained.

The pathological laboratory in such an organization is a very important part of the medical service and hospital. By the use of various tests, the clinician is assisted in accurate diagnosis and can then prescribe suitable treatment.

The X-ray department is equally necessary and effective in assisting the clinician with his diagnosis.

Other facilities provided are for physiotherapy, which includes light, heat, and electrical treatment and massage, a department for the treatment of skin diseases and venereal diseases, and an isolation hospital for the treatment and isolation of patients with infectious diseases.

Another essential service is the hospital laundry. It has often been considered that hospital laundry can be successfully processed at a well-operated and equipped central community laundry. That is a most unsatisfactory procedure, and anyone who has had experience of the condition of hospital linen, from the operating theatres and beds used for the treatment of infectious diseases, septic cases, severe burns, etc., will agree to the necessity for the hospital to operate its own laundry.

In modern hospital management the laundry supervisor controls the central linen store and issues supplies to the wards and all departments on a daily basis.

NURSING

However efficient the staff and special services may be, successful treatment of in-patients can never be achieved unless nursing attention is of a high order. This is a matter of teamwork.

When a patient is seriously ill or injured the margin

between life and death is often small. Constant vigil must be kept and the doctor's instructions rigidly adhered to.

Training of subordinate staff is a long process, and language problems, together with low educational standards, increase the time factor.

The role played by efficient nursing is at least half the battle in the treatment of hospital patients.

In his strictly professional sphere, the medical officer who serves abroad may encounter among his patients almost every known disease. He will find all the more common conditions, and rare ones too, of which he has had experience at home.

In the tropics and sub-tropics a host of new diseases confront him, and tropical medicine becomes a subject almost as wide and varied as all that he has already learned.

The effects of tropical diseases on the individual are horrid and stark realities. In different parts of the world certain diseases are predominant and take their heavy toll in human life and suffering. In many places evolution appears to have stood still for several millenniums, and it is somewhat of an irritation to the doctor to find so many apparently insurmountable barriers hindering progress towards a higher standard of living.

Many diseases result from malnutrition and bad sanitation, and the doctor becomes impatient when these defects are not rectified, but in certain vast, under-developed areas the effort and cost required to do so seems to present too great and overwhelming a task.

Over the years, however, and sooner than he himself appreciates, improvements take place and the evolutionary process proceeds at a faster rate than among the surrounding peoples. This fact in itself presents its own problems.

PUBLIC HEALTH

The public health medical officer is called upon to control general cleanliness of the areas of operation, and this in the East is always a major task. The breeding of the common fly and the supervision of the water supply must also be controlled. The inspection of meat and food often involves compulsory destruction of large quantities of foodstuffs as unfit for consumption. The supervision of soda water and soft drink manufacture, canteen kitchens, and all employed food handlers is another routine duty.

Epidemic and endemic diseases are always present in tropical and sub-tropical countries. Here it is necessary to mention such diseases as smallpox, cholera, typhus fever, relapsing fever, sandfly fever, malaria, yellow fever, undulant fever, typhoid, and a host of other parasitic, bacterial, and fungoid diseases.

The study of the cycle of these diseases may anticipate an outbreak. Cases of infectious diseases are often concealed from time to time in the bazaars and surrounding villages. In order to find them, friendly relations with local authorities and with village chiefs are necessary.

In the event of an outbreak of an epidemic, rapid counter-measures have to be taken, and these are often unpopular and costly.

In addition, there may be the added duty of control of port health, for there is no more rapid way of spreading an epidemic disease than by importation by ship or aircraft.

In conclusion—a word about the medical staff who serve abroad. They have a life full of interest, experience, and responsibility. They must gain the confidence of their own and local peoples. They are expected to be on duty twenty-four hours of the day and to be never too tired to undertake any task, however trivial. They are easy victims of criticism.

The doctor practises not only his own profession but is also frequently the father confessor of his patients. He is called upon to treat dogs, cats, and other domestic animals and even the prized rooster. He must at all times be prepared for an emergency—especially in the middle of the night. The telephone is his curse.

In spite of all these difficulties, medical practice overseas means a full and interesting life. Few doctors, who value the friendships they have made, the gratitude which has been expressed to them as a result of their successful efforts, or the deep feelings expressed without words in sorrow, can possibly regret one moment of their service.

MEDICAL FACILITIES ON FAR EASTERN OILFIELDS

By F. L. WEBSTER,* F.R.C.S.Ed.

This paper relates to experiences from 1924 onwards in Shell's associated companies in Brunei and Sarawak —Sarawak Oilfields Ltd. and British Malayan Petroleum Co. Ltd.—and to visits to the oilfields in Indonesia, including tobacco and rubber estates there and in Malaya, in all of which medical management of mixed Asiatic workers was run on similar lines.

In 1924 the medical establishment on the Miri oilfield consisted of two medical officers, one European nursing sister, and a number of Asiatic dressers, Chinese, Indian, Malay, and Sikh. These staffed a small hospital catering for the Asiatic labour force and, separated from it by some distance, including a wide river, a small wooden hospital with six beds for Europeans, which was in the charge of the English sister.

The Company's working population of all classes numbered about 4000 people at this stage, which included about 175 European employees, about 30 per cent of whom were married and had their families with them.

The oilfield labour force at that time were so-called "contract coolies," mostly from Hongkong and the surrounding areas of Canton, with a fair mixture of Tamils from India or Malaya and indigenous Malays and Dyaks. The indentured coolies did not have their womenfolk with them, and therefore the problem of treating families was not in the foreground. However, as the oilfield grew and became more settled, a number of these indentured coolies elected to remain in their country of employment and either brought in their womenfolk or married local ones. Before very long indentured labour of this kind ceased to be obtainable from India, Malaya, or China, and though recruiting in these areas continued, new arrivals tended to bring their families with them.

The mixture of races in the labour force with their different religious habits and customs made the staffing and running of a small hospital a little complicated. Each race required its own diet handled by its own people, and they would not readily occupy mixed wards. The Chinese were the easiest to please —Mohammedans and Sikhs were rather more particular. The majority of the Sikhs belonged to the local police force, for whom the Company made themselves medically responsible.

The oilfield medical policy at that time was that any labourer absent from work on account of sickness must be admitted to hospital, where he remained until he was fit to return to work on the day following his discharge. One of the reasons, if not the main one, for this was that all labour lived in "coolie lines," where each man possessed a bed and locker in a long dormitory, where it was manifestly impossible to maintain and treat sick individuals. When this type of living accommodation changed to smaller individual or family quarters, the policy nevertheless continued with little modification right up to the outbreak of hostilities in the Pacific in 1940. Control in this respect was by liaison with the labour and staff departments and cross-check of time sheets and hospital admissions daily.

From 1924 to 1934 the Miri oilfield grew steadily, and with the concomitant increase in population the old hospital accommodation was replaced gradually by more suitable buildings and the addition of much needed facilities, *e.g.* laboratory and X-ray equipment. Hospital wards were of the pavilion type commonly seen on big rubber and tobacco estates and Indonesian oilfields. These all became grouped together in one area so that the main surgical and other facilities were readily available for all classes of patient. Also during this period the Seria oilfield (discovered in 1929) was being developed, and it quickly became apparent that provisions for medical facilities would be required in the area for the workers. By 1930–31 a small hospital had been built and staffed in Kuala Belait.

MEDICAL STAFF

In addition to the Miri oilfield population there was a small riverside town of about 10,000 inhabitants, which also increased its growth in ratio to oilfield activities. This was inhabited mainly by Chinese Towkays and their families and merchant traders of other nationalities in smaller numbers. The local Government authorities ran an outdoor dispensary in charge of an Asiatic dresser, who was usually a man of some years experience. There was no Government doctor in the area. Accordingly, the Company's medical officers were paid a retaining fee by the Government to attend all classes of Civil Servants in the area and patients sent in from up-country by district officers. Private patients from the bazaar were admitted to the Company's hospital on payment of fees and hospital charges.

The Company's medical officers also did the official port health work for all ships calling at the port of Miri, including all tankers mooring at the Lutong refinery pipelines seven miles up the coast and three and a half miles out to sea. One or both medical officers sat upon a municipal Sanitary Board, the formation of which largely resulted from their efforts, the other members being the district officer and the representatives of the Chinese Chamber of Commerce, which they had formed amongst themselves. The

* The Shell Petroleum Co. Ltd.

active practical work resulting from the Board's activities, which was financed by the Government, was performed by Asiatic sanitary inspectors appointed by Government and Company. In 1924 the Company's medical department had set up a public health establishment of its own, staffed by Asiatic sanitary inspectors with the qualification of the Royal Sanitary Institute, obtained by sitting the examination in Singapore. In addition, larvae catchers were recruited and trained in anti-malarial investigation, and put in charge of a small labour force engaged in clearing, ditching, oiling, and similar work.

This public health section was under the direct supervision of the senior medical officer. To begin with it was a little difficult to establish the budget expenditure involved. By modest beginnings the initial inertia was overcome, and the rapidity with which the work accomplished produced the most satisfactory results soon led to full appreciation of its value.

The activities of the medical department thus became soundly established on the necessary clinical and preventive lines, which were most pressingly needed. The control thus exercised by the Company medical officers over the population as a whole was of great value to the area, as it provided unity of control of public health and hospital work. It was also, of course, an exercise in versatility for the Medical Officers themselves, providing them with medical interests over a wide range.

HOSPITAL ADMISSION CASES

Although wives and children of employees admitted to the Company's hospital paid only a small sum to cover the cost of their food, owing to some mistrust of occidental medicine, many cases refused to be admitted in the early years. As time went on, this unwillingness to enter hospital became much less pronounced, and the daily bed state of the hospital showed an increasing percentage of non-employee patients. The rule of admission to hospital of all labour force illness of every description gave a hospital admission rate which was rather fictitious in comparison with hospital admission rates in non-tropical countries. A large number of admissions were for short term illnesses, and the average number of hospital days per admission was usually below seven.

Between the years 1924 and 1948 the character of morbidity encountered in the hospital practice changed quite materially. At the outset the wards were full of serious cases of malaria and dysentery with a high mortality rate. This was the natural outcome of the low grade sanitary conditions in all dwelling areas, and up to 1923 the almost complete absence of active anti-malarial measures, even in the most closely populated areas. In fact, the bazaar area of the town of Miri, where private Asiatic enterprise lived, presented such a fearful picture of non-sanitation that it looked a more than Herculean work to put matters right. Once the Company's health department and the Miri Sanitary Board began to be properly established, malaria in the areas as a whole steadily declined, seasonal epidemics were shortened, and eventually by the early 1930s malarial infections acquired in the areas under control were practically nil. In the worst area of all, the refinery at Lutong, where the carrier was the salt water breeding *A. Sundaicus*, the establishment of tide gates to exclude salt water from the drainage system reduced the incidence of malaria in this segregated area to nil. It is interesting to note that although the Miri and Lutong areas remained virtually free of malaria during the years 1930 to 1939, the onset of war conditions, starting with the movement of police and troops into the area, immediately produced the first malarial epidemic for many years. This was fairly rapidly got under control, but under the Japanese occupation of the country, all anti-malarial measures ceased, and malaria again became as rife as it had been in the early years of the oilfields' life. Again post-war measures, including the use of DDT and the drug prophylaxis reduced the incidence to nil after some two years of continuous effort.

Concomitant improvement in general sanitation relieved the situation with regard to dysentery, and no epidemics occurred after 1926, until the time of the Japanese occupation.

In the early days many cases of true ankylostomiasis were seen with severe oedema and anaemia. These cases also disappeared rapidly from the scene, although between 60 and 70 per cent of hospital admissions continued to show the presence of ankylostoma ova, though without overt clinical symptoms.

INFANT MORTALITY RATE

Another great change over these years occurred in infantile mortality. It was estimated that in native Kampongs and Chinese inhabited bazaars, the infantile mortality in the first twelve months of life was between 300 and 400 per thousand. When wives and children of Asiatic employees of all kinds increased in numbers, it became possible to start ante-natal and infant clinics, which not only served their immediate purpose but also formed a useful example to the indigenous non-Company people, who very promptly appreciated the advantages and began themselves to attend in satisfactory numbers. The Chinese were our most progressive and helpful patients in this respect, the more conservative Malays were slower, but in the end became quite enthusiastic. In later years it has become possible to accommodate the different races in hospital wards arranged more on the accepted pattern. Racial dietetic arrangements still have to be made, but as long as distinction between Mohammedan and other religious denominations is observed, the Asiatic patient seems to be easier to feed than was formerly the case.

NUTRITIONAL DISEASES

A satisfactory standard of nutrition in the Company's labour force was maintained by the regular issue of food stores, such as rice, salt fish, fresh vegetables, pickled eggs, salt, and tea. This issue of rations was the most important contribution to the prevention of beri-beri. The aetiology of this disease was only just becoming properly understood, and as knowledge progressed, it was found that the provision of these rations had largely solved the problems in relation to this disease in a rather empirical manner. Beri-beri did not return, and was not seen in its very serious aspects, except occasionally in Chinese infants, until the Japanese occupation of 1940 to 1945.

INFECTIOUS DISEASES

There were many cases of fevers of unknown origin, and when Fletcher and Lewthwaite did their work in Malay on typhus it was possible to identify the prevalence of both rural and urban varieties in the Company's areas. In the course of serological work in this connexion, it was discovered that typhoid and paratyphoid infections were commoner than had been supposed.

In this part of Asia tuberculosis of the lungs has always been common, and is now the disease taking foremost place in severity throughout the area. The long term nature of this condition and its cousin leprosy, which is also endemic throughout the area, though luckily in small numbers, has always made them a difficult administrative medical problem. At one time it was possible to repatriate indentured labour suffering from this disease to their country of origin. Latterly this became more difficult, as the number of expatriates declined and the population became indigenous.

The magnitude of this tuberculosis problem has been fully appreciated, and all over Malaya Government authorities are establishing investigation, control, and treatment facilities. The oilfields have assisted in this matter, but it has become their policy to regard these two conditions as a matter of public health for which Governments are primarily responsible. With this in view, the Company in its Borneo fields have assisted by giving materials and equipment to establish a tuberculosis clinic in Miri, Sarawak, in which Company doctors will perform clinical work, though administratively and financially it will be under Government control. Cases of pulmonary tuberculosis occurring in the Company's labour force will continue to be investigated in the Company's hospitals. It is, however, policy to transfer such cases to the care of the tuberculosis clinic as soon as this changeover can reasonably be made. Surgical cases may be treated in the Company hospital until convalescent.

For some years past, there has been a flourishing leprosy settlement near Kuching, and all cases occurring on oilfields were transferred here, so the situation with regard to this disease was much easier and more satisfactory than in the case of tuberculosis.

MENTAL DISEASES

Another administrative problem was the care of cases of insanity, which maintains a steady prevalence in Asiatic races. Here again, the Government of Sarawak have maintained a mental hospital in Kuching, where the majority of the Company's cases have been cared for at the Company's expense.

SURGICAL FACILITIES

In earlier years proper facilities for surgery were almost negligible. The need for more and more surgery became apparent as the population changed its character to a more settled community. Once safe and reliable surgical facilities had been established, there was an increasing demand for their use. Here again the Chinese submitted themselves most readily to surgical treatment, but one must not omit to mention the Dyak in this respect. For certain conditions prevalent amongst themselves, *e.g.* goitre and thyroid adenoma, elephantiasis and congenital or traumatic deformities, the Dyaks were enthusiastic patients, and often travelled many miles by river and sea to seek treatment.

Carcinoma was a rather uncommon disease. When seen it was mostly in the Chinese race and affected the stomach and naso-pharynx. The latter type may be said to be endemic in Hongkong and surrounding parts of Canton, where it has been studied and described by Digby.[1]

TRAINING FACILITIES

One of our main administrative medical problems was the training of Asiatic medical staff or the recruitment of dressers and nurses trained elsewhere. The educational facilities in Malaya were very largely absorbed by Asiatics who eventually entered the Government medical service. Accordingly, the Company had to establish its own courses of instruction, and this enabled it to pick out the brightest individuals. These, with the kind assistance from the Government, were passed on to the proper schools in Malaya, where they could obtain official qualifications as dressers or nurses.

As mentioned above, the possibility of recruiting fully trained inspectors with the Diploma of the Royal Sanitary Institute obtained in Singapore was the basis of the successful public health section. Quite a number of the more experienced dressers and nurses were entirely locally trained, but were unfortunately without any official qualifications. It was remarkable to observe how efficient a Chinese of the coolie class could become as an operating room assistant or ward attendant.

One of the great needs amongst the Asiatic popula-

tions working on oilfields is the provision of domiciliary midwives. Apart from the fact that midwifery is badly neglected amongst most Asiatic people, an effort to relieve the overcrowding of obstetric beds in hospitals is a chief aim. The great majority of childbirths are normal amongst Asiatic people, and there is no necessity to admit them to expensive hospital beds. With this in view, some effort was made to train Asiatic girls to be visiting midwives, and they have proved very successful.

MEDICAL EXAMINATIONS

An important point of medical policy adopted early with indentured labour requires special mention. This was the examination of all new recruits. For this purpose every batch was admitted to hospital for a period of at least one week. During this time full examination of each man was done. This included blood examination, detection of parasites, treatment of skin diseases and other morbid conditions found. No man was allowed to leave the hospital until he was fit, and those with chronic illness of any kind were repatriated without delay. An ambulatory medical examination had been carried out on most of these coolies prior to leaving their home port, and it was illuminating to see how many cases of parasitic and other diseases had eluded the examiner. It was this fact which directed the policy of admission to hospital, and it was fully justified by the manner in which it raised the general level of physique and nutrition in the labour force. In modern days these examinations are done under outpatient conditions, although the same pathological tests are still carried out. Only cases of overt disease are admitted.

STAFF AND BUILDINGS

The Medical Department on these oilfields today has seven Medical Officers, an English laboratory technician, and an English hospital administrator. The Asiatic staff has correspondingly increased its numbers.

It is hoped that the construction of an entirely new hospital of a permanent type to replace the present post-war pavilions will be started in 1955. This new hospital will be situated on the outer limit of the Seris field about halfway between Seria and Kuala Belait and in the vicinity of the Panaga golf course. The hospital in Miri, Sarawak, is also scheduled for replacement on a different site in the near future.

Reference

[1] Digby, K., Lai, F. W., and Che, Y. T., *Brit. J. Surg.*, 1941, **28**, 517.

DISCUSSION

The President: You will agree with me I am sure that we have listened to two very constructive and enjoyable papers. I now have the pleasure of asking Dr Levin, who has been good enough to place himself at our disposal, to open the discussion.

Dr A. Levin: During the past sixty years the oil industry has led the field in industrial medicine, and it is a tribute to this Institute that it has appreciated the value of medicine in the industry.

I have recently visited Trinidad in order to review the medical services in that country, and I would like to mention some of the problems which confront my company at home and abroad. Dr Dolly, who is my Company's second in command in Trinidad is also here this evening, will give us an account of a few first hand experiences, so I shall confine my remarks to general problems of policy.

It is highly important that the medical department must have the full support of the management and the "top management." I am fortunate in my own work in that the chairman, Mr S. J. Vos, takes a personal interest in the medical department, and both managing directors give every possible help. Next in importance is close liaison with the personnel department. It is impossible to run a medical department satisfactorily without the maximum amount of help and advice from the personnel officers. It is useful to consider medicine in industry in three divisions: first, that of preventive medicine, of which the previous speakers have quoted good examples; secondly, constructive medicine; and, finally, curative medicine. As Dr Webster suggested, it is clear that curative medicine is of least importance to industry in the final analysis compared with preventive and constructive medicine. By the time an employee is off sick he is of least value both to himself and to the Company, and I would like to look to the future when industry will play an even larger part in preventive medicine and "positive health."

The oil companies have shown the way in medical services abroad, and it is now up to local governments to give facilities for curative medicine, so that the medical department of an oil company will in time devote itself to keeping people fit and helping to select those who are suitable for the jobs required. In most companies I believe there is now a preplacement examination carried out, and we in our Company divide people into categories "A," "B," "C," and "D."

We find there are usually a small number in "A," that is to say people who are absolutely fit; the majority are in "B," those who have some minor disability but can carry on work quite normally; a small number in "C" require careful observation by the medical department; and a very small number in "D" are unsuitable for employment. The aim is not to pick out those who are unsuitable, but to find the suitability of a man for his job, and that is where the personnel department must have close liaison with the medical department. A man may have flat feet and be perfectly suitable for a clerical job but may not be able to manage a heavy engineering job.

Another part of constructive medicine is to have a careful follow-up system, so that the man who is graded "C" can be kept fit and at work. Sometimes there are cases of doubt, such as a man who is found to have sugar in his urine. He may or may not be a diabetic, and this can be discovered only by blood sugar analyses. In either case it is easy for a medical department to watch him over the years and give him the confidence which he may require. In the U.K. it is essential that the in-

dustrial medical officer has the best possible relationship with the general practitioner, as all treatment should be carried out by the man's own doctor but, wherever necessary, the industrial medical officer is there to help, and may have the backing of his Company to give extra aid when required.

It would now like to mention some of the future problems of my Company's particular service in Trinidad. Local medical facilities are rapidly becoming adequate, and I feel sure that the future for the curative part of the medical service will be to use local doctors wherever possible.

We have commenced a small experiment, which will be of interest as the years go by. Recently, a very fine new dispensary has been built, and a local dental surgeon has been placed in charge of three of its rooms. He has been given the accommodation and will be allowed to charge fees on a scale agreed by the Company. He will run the department entirely by himself and, I am sure, will make a success of it. In my opinion this is the only way to control the ever increasing expenditure which can become a burden to any Company. I can visualize this type of procedure being carried further by employing doctors, both general practitioners and specialists, on the same basis, working in close conjunction with the medical department of the Company. At present this may be impossible in some parts of the world where full service will still have to be maintained, but I am sure it will be the ultimate aim of all oil companies.

Dr Webster talked about midwifery. My Company has a large midwifery centre in Trinidad—in fact about four hundred babies a year are delivered. I consider that this is not truly a part of industrial medicine, and when local facilities are forthcoming we must make use of them. Dr Webster mentioned the native mistrust of occidental medicine, but I may say this occurs not only in the tropics, but also in Trinidad, where the sale of patent medicine is phenomenal, and the use of the unqualified practitioner is not unheard of !

The real success of a good medical service depends entirely on the genuine interest of the management, the loyalty of the employees, and the constant care of the medical staff. The doctor has to be exceptionally competent. He must be a good diagnostician and must be able to put his mind to almost any problem. It is quite remarkable how knowledgeable the doctor in industry becomes and what a fine job of work he does both for the Company and for the employees under his care.

Finally, I would remind you that we are still making advances in this part of medicine, and although the facts of progress may be written on pages of history, progress is not a law of nature. You may see the work of one generation dropped in the next, but medicine advances characteristically by trial and error. I look forward to seeing in the future a new era of preventive and constructive medicine, so that the need for curative medicine will grow less and we shall all be able to work together in the best possible health.

Dr Dolly: I would like to draw a comparison between the medicine practised on the island as a whole and that practised in connexion with the oilfield. There are few epidemics, such as those described by Messrs Turner and Webster—we have occasional typhoid and dysentery cases, but that is about all. The general health of the inhabitants is guarded by the public health service, and comparing the oilfield service with that of the public health, I think that the former is one which we can be justly proud of.

Dr Levin mentioned midwifery. I am very interested in it, and I have urged Dr Levin to keep the births down. Although this subject may not be of much interest to a group of petroleum technologists, I would like to mention that in those areas where we have concentrated to a large extent on midwifery, if we compare our results with those of the island generally, we have something to be very proud of. Dr Levin says we have something like 400 deliveries per annum. For three years prior to my joining the Company, I was in charge of the maternity department of one of the large hospitals in Trinidad, and I was responsible for about 900 cases a year, on average. Today, however, every case which comes to us has received ante-natal treatment, whereas in the Government service we were forced to take cases, many badly nourished ones from the outer districts.

Although I have not the figures with me, I can tell you that, on an average, one of the worst complications in midwifery was cancer. I used to deal with thirty or forty cancer cases a year in the medical service, whereas in the ten years of my appointment in the oilfields, I have had, I think, no more than six, and that I put down entirely to ante-natal care.

Mr Turner referred to the question of eye diseases. In Trinidad these are fairly frequent, but in the oilfields they are a rarity. We have had cases of accidental injuries to eyes, but in the oilfield itself I can not recall many eye diseases as such.

He also referred to trachoma. In the West Indies this disease is a rarity. For a number of years I was assistant to an ophthalmic surgeon, and the only cases of tracoma that we saw were in Indians and Chinese, who came over as emigrants, but in the West Indians of African origin I have never seen a case of tracoma.

Another subject that I would like to refer to is tuberculosis. In Trinidad we are very fortunate in having funds which are to be devoted to an island-wide B.C.G. campaign. A recent survey revealed that the incidence of tuberculosis among employees in the oilfield and the refinery areas was considerably less than in the remainder of the island populace. The incidence of tuberculosis among the young was practically nil; but this meant a lot of work, because all those persons who had not been infected by tuberculosis had to be inoculated.

There have been a few cases of lead poisoning. I am particularly interested in this aspect of medicine, because I happen to be the medical officer appointed by the TEL suppliers for the examination of lead blending operators. During my three years of office, I have held regular blood examinations and so on, for the men employed in lead blending. So far, I have had no case in which lead has adversely affected the employees.

Dr Webster mentioned cancer. I think we are particularly fortunate in not having much cancer, but this is probably due to the fact that most of the employees are outside the age group in which cancer occurs. Most retire before the age of sixty, and their wives, who are usually younger, have not reached the cancer age group.

Dr T. E. M. Wardill: There is one thing that we doctors occasionally lose sight of in our work, particularly in our pre-employment examination, when we say that a man is fit. That is, we can not readily answer the question "Fit for what?" This is because fitness is purely relative to the work that is to be done. A man may not possess the special physical capacity required for geological work, whereas he may be perfectly capable of working in a static occupation in an office. In pre-employment examinations I feel that we should make a plea to select the man for the job, rather than take the universal category, or the universal standard of fitness for the employment.

The Army, as you probably know, adopts a coding system, where a man is given a code number and where he might quite well be a telephone operator one day or a clerk the next. We should therefore try to enforce this national tendency desired by the Government, that a man should be selected and examined for the particular job he is going to do.

Dr Norman: The thing that impressed me most in reading Dr McClean's paper was the extremely wide variety of occupations that he had to deal with, varying from train drivers to tanker crews, home clerical staff, and overseas tropical management.

Dr Webster has described some of his personal experiences during thirty years in the tropics, in which he has seen the whole development of public health take shape. In a quarter of a century there has been a complete change in the picture of tropical diseases, until now many of the more serious conditions have been virtually eliminated. I suppose that this change has altered the problems very considerably; perhaps the chief ones are those of nutrition and over-population, rather than epidemics or infectious disease.

V. Biske: There are one or two points which I would like to put to our speakers, for their views.

Have they any statistics available showing the incidence of sickness in the petroleum industry in various parts of the world? According to the figures issued by the Ministry of Labour and National Service the average absence, due to sickness and injury, among the 23 million employed population of the U.K. is between 4 and 5 per cent. How does the oil industry at home and overseas compare with this?

Secondly, in connexion with the remarks made by Dr Webster about native remedies obtained in the local bazaar. Has investigation of any of these remedies shown anything of value? There are one or two cases of this kind on record in the U.K., such as the old foxglove remedy for heart trouble, which was found to have a basis in the digitalin content of this plant, and, more recently, the proven value in obstetrics of the raspberry tea long prescribed by midwives. Has anything similar been found among Oriental folklore remedies?

Finally, concerning tests as to suitability for employment. Are such tests confined solely to physiological tests, or is any value to be attached, in the opinion of the speakers, to psychological assessment, either by what may be termed purely psychiatric tests or else by those having a more physical approach, such as electric recording of reaction times, sensitivity of touch, and similar biometrical investigations?

J. S. Parker: It is now over twenty years since I worked in tropical or near tropical conditions. In those days two diseases affecting labour were prevalent which have not been mentioned, even though the scope of the diseases covered has been wide. Hookworm was common in Trinidad, and bilharzia was common in Egypt. Both diseases are somewhat similar in their method of infection, and result in a considerable lowering of the energy of the person affected. One Trinidad oil company spent a considerable amount of time and money in a campaign to wipe out hookworm. Do I understand that through the endeavours of the oil companies these diseases are no longer prevalent amongst their employees, or is it that they have been overlooked in the general scan of tropical diseases?

Dr F. L. Webster: Regarding the form of cancer which I mentioned, the first sign is usually enlargement of the glands in the neck, and by the time that has happened the disease is already far advanced. Digby recorded a large number of cases which occurred in Hongkong, and wrote an interesting paper on the subject. The remarkable thing about the disease is that it seems to be endemic, if not confined almost entirely to Hongkong and that area of Canton. Nobody knows why, and many people thought that there was perhaps some significant factor in this locality which causes a particular kind of cancer. There was much hope that some light might be thrown on the cause of cancer by studying it, but, as far as I know, nothing has eventuated so far.

If I may reply to Mr Parker's enquiry about ankylostomiasis and bilharzia, I can say that in regard to ankylostomiasis, in most areas where prophylaxis has been established, we no longer see those cases of severe anaemia and other serious defects keeping a person from work as were visible some twenty-five to thirty years ago. As a matter of interest, I do not think they recurred to any great degree even during the Japanese occupation of SE. Asia.

In regard to bilharzia, the story is rather different, because the fluke still infects the inhabitants of N. and C. Africa, and causes much pain and discomfort. Although there are remedies which will deal with it, the medical profession has not yet discovered specific drugs such as those for malaria, and all the diseases which anti-biotics, *e.g.* penicillin, will cure. Treatment of bilharzia is still hampered, as it were, by an Achilles heel, but no doubt the pharmacologists will discover a remedy in the near future. Here again, however, control of the vector, *i.e.* prevention, may be the most effective answer.

I fully agree on the matter of nutrition coming very much more into the picture in the future.

Besides improved nutrition, improved obstetric care is another thing which is increasing our population. I fear some people blame the doctors very heavily for that, but when it is said that obstetrics are not for the oil industry, it does not mean that it is desired to stop the ante-natal clinics or the keen obstetricians in their work —far from it. If people are encouraged to bring up their children so that their expectation of life from birth is increased from what it used to be, *i.e.* about fifteen years, in the tropics generally, the nutrition of the community in general must be improved. On good oilfields you will find that the cultivation of small gardens, providing fresh vegetables and so on, is very properly encouraged. In Malaya, for example, workmen are encouraged to grow tapioca and sweet potatoes, and other forms of food of that description, which can be of very great value.

So, nutrition is going to form a very large part of the picture, and Shell has, in fact, already developed what one might call an agricultural department. Perhaps the production fields will have them in future. The Company's present agricultural endeavour is mostly concerned with the production of chemicals which do away with insect and weed pests. When pest control in general is as efficient as that for dealing with malaria parasites, the Company may start thinking about growing food. So we may yet see an agricultural department, which can assist in improving the poor-quality soil of oilfields.

As regards sickness statistics in the petroleum industry, they are very difficult to collect. As far as I am concerned personally, on fields that I know best, all my records were destroyed by the Japanese invasion, and although I was looking forward to studying those at home when I had the time and leisure, I have not been able to do so. I rather feel that my friend Mr Turner is probably in a better situation than I am in that respect. However I would say that, judging on ordinary general observation, the rate of sickness amongst Asiatic oilfield employees is really remarkably low. It all depends what terms you put it in, but I should say that the average Asiatic employed on an oilfield hardly ever loses more than ten to fifteen days work in a year, if he loses as much as that. They are very prone to get bronchitis, and perhaps a touch of pneumonia working on rigs, etc., on cold and wet tropical nights, but that does not always keep them away from work very long, and altogether I think that the sickness absence is very creditably low.

In regard to the use of psychiatry in the oil business. The best sort is the common sense variety, any experienced industrial relations man or doctor gathers th

by experience of the types of work which people have to do, because it does not take very long to look at a man on the other side of a desk and say, " Well, he would never climb derricks, or he would never go down in a caisson, or work with a pickaxe, and so on," and one can very shortly become a very competent judge for all practical purposes. The higher forms of psychiatry are not for anybody but very special cases of real mental trouble.

Mr A. C. Turner: I am very fortunate because Dr Webster seems to have answered adequately all the questions raised.

I could not agree more regarding this subject of pre-employment medical examinations, and particularly on the point of a special psychiatric investigation. I associate myself with his view that common sense is better than all the information gained by narco-analysis.

Mr Parker mentioned bilharzia. I have seen quite a number of cases of bilharzia in my twenty-five years in the tropics, but in the area where I was practising it was not indigenous, and all the cases were imported. It was not a local problem, and we were never able to identify the intermediate host—the water snail—in any of our areas.

Mr Biske brought up the question of sickness rate. We kept, I think, quite accurate sickness records. We called it " percentage time lost through sickness," and it varied, of course, from one station to another, but I should say that between 4·5 and 5 per cent was the answer—that covered staff, both ex-patriate and locally recruited, and labour.

I was very interested in two of Dr Dolly's remarks: (1) That he had had no case of obstetrics that had not previously attended the ante-natal clinic. That, I think, was very lucky. Not that I did any obstetrics myself, but I used to hear the people who did complaining about the number of cases that were dumped on the doorstep halfway through labour. (2) Also, I find it rather interesting that he mentioned the absence of trachoma in his part of the world. It is a very serious business, especially in the countries which stretch between the Eastern Mediterranean and, I should think, as far as the Far East.

The question of malignant disease, or carcinoma, was raised. My experience has been that the number of cases was very small, compared, for instance, with the incidence in the U.K. I am prepared to admit that we were dealing largely with an age group not prone to cancer and that there were no accurate statistics of the cause of death to cover the countries concerned. Still, my impression is that carcinoma has a lower incidence than it has in the Western Hemisphere, but like some other pathological conditions it was on the upgrade. To mention one of these other conditions, that comes to my mind—appendicitis. I think it was Rendle Short who suggested that the striking increase of this disease in Britain might be caused by the more universal consumption of the roast beef of old England. I am bringing this point up, because in my early experience appendicitis was a rarity, while in latter years it was much more common, in native-born peoples. I am suggesting that the cause might be the trend of those peoples towards the Western way of life.

To revert to the subject of carcinoma. We hear all this talk of increases in the incidence of carcinoma of the lung today. This might seem to indicate a further development in the cycle of this disease, for, I never saw a case of carcinoma of the lung, other than in European races.

The President: We have had, not only a pleasant, but a most instructive evening for this the first occasion on which we have had a medical discussion under our aegis. I trust it will not be the last, and perhaps the next time we can discuss some aspects of industrial medicine in relation to petroleum production and use.

The organization that we have heard about must make us feel that the oil industry is about the best industry to be in if one is going abroad. Whatever else the oil industry has to pride itself upon, its humanizing effect on the countries into which it permeates has been really astonishing. It is not only the standard of living that is centred on the hospitals, it is also the medical attention which is provided by them. I do not know to what extent that is due to the natural professional and scientific outlook of the doctors. Largely, I feel it is due to their own personalities. They always seem to have those attributes we credit them with, and I, for one, go on admiring the doctors the more closely I become associated with them.

In both our speakers I noted the common sense approach to medical appraisal. Even the layman appreciates that view in his " semi-anaesthetical " condition, though there is undoubtedly much help to be gained from the statistical approach, which, at the present time, is causing us so much apprehension in regard to cigarette smoking.

I should like to propose a sincere vote of thanks to our speakers and also to our visitors and members who have participated in the discussion.

The vote of thanks was accorded with acclamation.

HYDROCARBON RESEARCH GROUP REPORT FOR 1953

INTRODUCTION

1953 is the tenth year of the existence of the Group in its present form, and this in itself is perhaps a reason why the report should include a general statement as well as detailed results of the year's activities. The written records of the Group's activities as a whole are not many, and it therefore seems well worth while to review the changes which have been brought about within the Group, the results of the Group's actions, the reasons for its formation, and its continuing activity.

HISTORY

The Group originated as a result of co-operative work on hydrocarbon analysis, sponsored during wartime by the Ministry of Aircraft Production. This work was concerned largely with the use and development of spectroscopic methods for identifying hydrocarbons and the synthesis of standard hydrocarbons of high purity. In 1944 this programme, with its financial commitments for sponsoring work in certain universities, was taken over by a group of five major companies, concerned with petroleum production, and the Ministry of Aircraft Production. Each member organization undertook to make available £1000 per year.

In the first year the Hydrocarbon Research Group was concerned " with physical properties of hydrocarbons, with particular reference to spectroscopy." [1] The Group supplied a means of sponsoring fundamental scientific research in universities on problems of hydrocarbon chemistry of interest to the petroleum and related industries.

RELATIONSHIP WITH THE INSTITUTE OF PETROLEUM

The funds of the Group have always been derived entirely from contributions of the member organizations, whose representatives allocate the funds to university research. From the beginning, however, the Group has had the advantage of close relationship with the Institute of Petroleum, not only by obtaining from its administrative services, but also by being considered almost as a sub-committee of the Research Committee of the Institute.

The Chairmanship of the Group is always held in rotation by a representative of one of the member organizations of the Group. The Group Chairman is *ex-officio* a member of the Institute Research Committee, whereas the Chairman of the Institute Research Committee sits as a non-voting member of the Group.

SUMMARIZED ACTIVITIES—1944–53

Much progress has resulted in the spectroscopic fields originally sponsored by the Group, but the encouragement of research has been carried out on a much wider basis, with the result that the Group's activities now cover a very broad field of hydrocarbon science. Originally the work was of interest almost only to the oil industry, but now it has become of comparable value to the fuel industry in general and to the chemical industry.

The widening of the Group's field of interest has resulted in the formation of three Panels :

(*a*) Spectroscopic Panel, covering absorption spectroscopy.
(*b*) Hydrocarbon Chemistry Panel.
(*c*) Mass Spectrometry Panel.

The member organizations appoint specialists as members of these Panels, which also have as co-opted members leaders of the academic research teams receiving sponsorship.

The Spectroscopic Panel continues the original technical activities of the Group, and, like the other Panels, is responsible within its field for making recommendations to the Group for sponsorship of research programmes in suitable universities. It also allows for the regular meeting of academic and industrial research teams for discussion of the problems and advances in absorption spectroscopy.

Much progress has been made in this field during the ten years under review, and no little part of the British contribution is due to the sponsorship of the Group. The industry has undoubtedly benefited through these advances, particularly in the development and improvement of spectroscopic apparatus, the accurate mapping of absorption spectra of pure hydrocarbons, and the correlation of data to allow the facile and wide use of absorption spectroscopy as a general analytical method.

The Hydrocarbon Chemistry Panel was formed originally as a Hydrocarbon Synthesis Panel to supply the need for pure hydrocarbon samples for spectroscopic calibration. The synthesis programme commenced in wartime, but had considerable scope and needed much detailed and original work by the universities concerned before it was completed in 1948.[2] A wide range of paraffins, *cyclo*paraffins, and substituted aromatic hydrocarbons were prepared in as pure a state as possible, and made available as standard products for the teams working under the Spectroscopic Panel.

Since 1948 the interests of the Panel have become broader, and until the present year have been directed

largely towards the encouragement of research in the organic chemistry of hydrocarbons. This is a broad subject, and the Group's funds have allowed good progress to be made in university laboratories, on oxidation of olefins, use of the Grignard reaction in the preparation of hydrocarbons, halogenation of hydrocarbons, use of sodium alkyls and aryls for synthetic purposes, and in inter-relationship between structure and physical properties.

The Mass Spectrometry Panel was formed in 1948 to encourage the application of the mass spectrometer to hydrocarbon work. As in the case of the Spectroscopic Panel, the value of its activity must not only be in sponsoring of work in universities, but also in providing a meeting ground for academic and industrial scientists interested in the subject. Such a pooling of interests and experiences is of great assistance in a new subject, particularly in matters concerning the application of a new technique to industrial problems. In this case it was made the more valuable by the very active participation of one of the major British instrument manufacturers. Through the Panel, co-operative analyses have been arranged to check reproducibility of mass spectrometers and several research projects have been sponsored.

The progress made under the sponsorship of the three panels has been very real, but is difficult to summarize in a short space; an excellent fuller but still brief account has been made available by a past Chairman of the Group,[3] and the detail of the advances made in the sponsored research groups is available in very many scientific papers.

The Hydrocarbon Research Group has given one of the few, if not the only case of co-operative sponsorship of university research work during the past ten years; although it has not attempted to deal with any specific and objective problem of interest to a single member organization it has, through encouraging work on scientific problems of general interest to petroleum fuel and chemical industries, retained its original membership and expanded it until now it covers a very broad section of British chemical industry and Government scientific activity.

REPORT FOR 1953

The eight contributory member organizations of the Group were Anglo-Iranian Oil Co. Ltd., Esso Development Co. Ltd., I.C.I. Ltd., Ministry of Supply, Monsanto Chemicals Ltd., National Coal Board, The Shell Petroleum Co. Ltd., and Trinidad Leaseholds Ltd., giving an annual income of £8000. The expenditure for the year amounted to £8244 7*s*. 6*d*., of which £7872 10*s*. was made up of direct grants and honoraria to universities. With the credit balance at the beginning of the year this left a credit balance at the end of the year of £1417 18*s*. 3*d*.

The grants to universities are made against the recommendations of the three separate Panels of the Group, namely the Spectroscopic Panel, the Mass Spectrometry Panel, and the Hydrocarbon Chemistry Panel, all of which have been very active during the year.

The Spectroscopic Panel sponsored work (£2142 10*s*.) at King's College, London, Cambridge University, and Oxford University—the latter having been most productive of results and publishable papers (nineteen published, twenty-five prepared for submission). Much of the work is of a basic character and contributes largely to the understanding of the particular and related physical phenomena as well as leading to the development of new instruments and techniques. It is proposed to continue the assistance on a similar scale at the same schools in 1954.

The Mass Spectrometry Panel continued sponsorship (£1280) at King's College, London, Birmingham University, and Liverpool University. Good contributions to the field have been made by these laboratories, and several of the young men who have been helped have obtained doctorates and entered industrial or government research laboratories. A co-operative analysis programme has demonstrated the comparable accuracy of British and American instruments. Late in the year the Panel organized an outstandingly successful Conference in London, when twenty-three largely original papers were read to, and discussed by, a gathering of over 160. Both audience and authors were international in character. Publication of the proceedings is intended during 1954, and there is every sign of the conference finally proving a scientific and financial success. Mr J. Blears, of Metropolitan Vickers Electrical Co. Ltd., retires from the Chairmanship of this Panel, which he has most ably filled since its inception five years ago. Dr R. R. Gordon of the National Coal Board will be taking his place.

The Hydrocarbon Chemistry Panel maintained its sponsorship (£4450) at Bedford College, Birmingham University, and Queen Mary College. Thirteen papers have been published from these groups, and progress has been made in all the subjects under investigation. Largely, however, this work has become unconnected with other Panel interests and is chiefly of value for research training only. As a result much discussion on the future of this Panel's activity has been held during the year, leading to decisions to cease sponsorship of work at Bedford College and Birmingham after reasonable notice. The Queen Mary College work will continue, and after a temporary break, work at Oxford will be revived. More important perhaps is the intention to assist new programmes of work in physical chemistry of hydrocarbons with the hope of developing or improving new analytical and process techniques and establishing basic information of general value to the industry.

J. W. Barrett,
Chairman.

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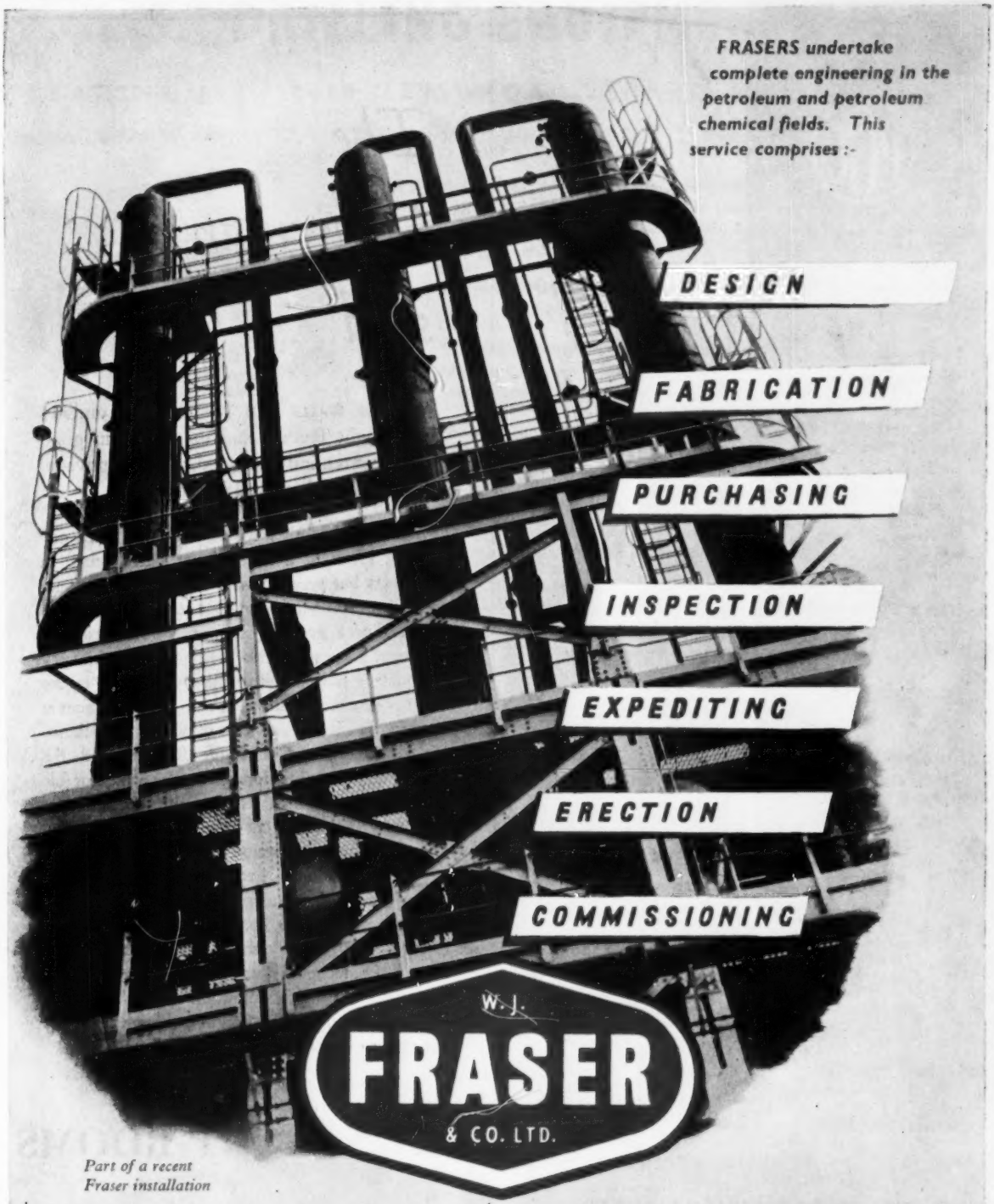

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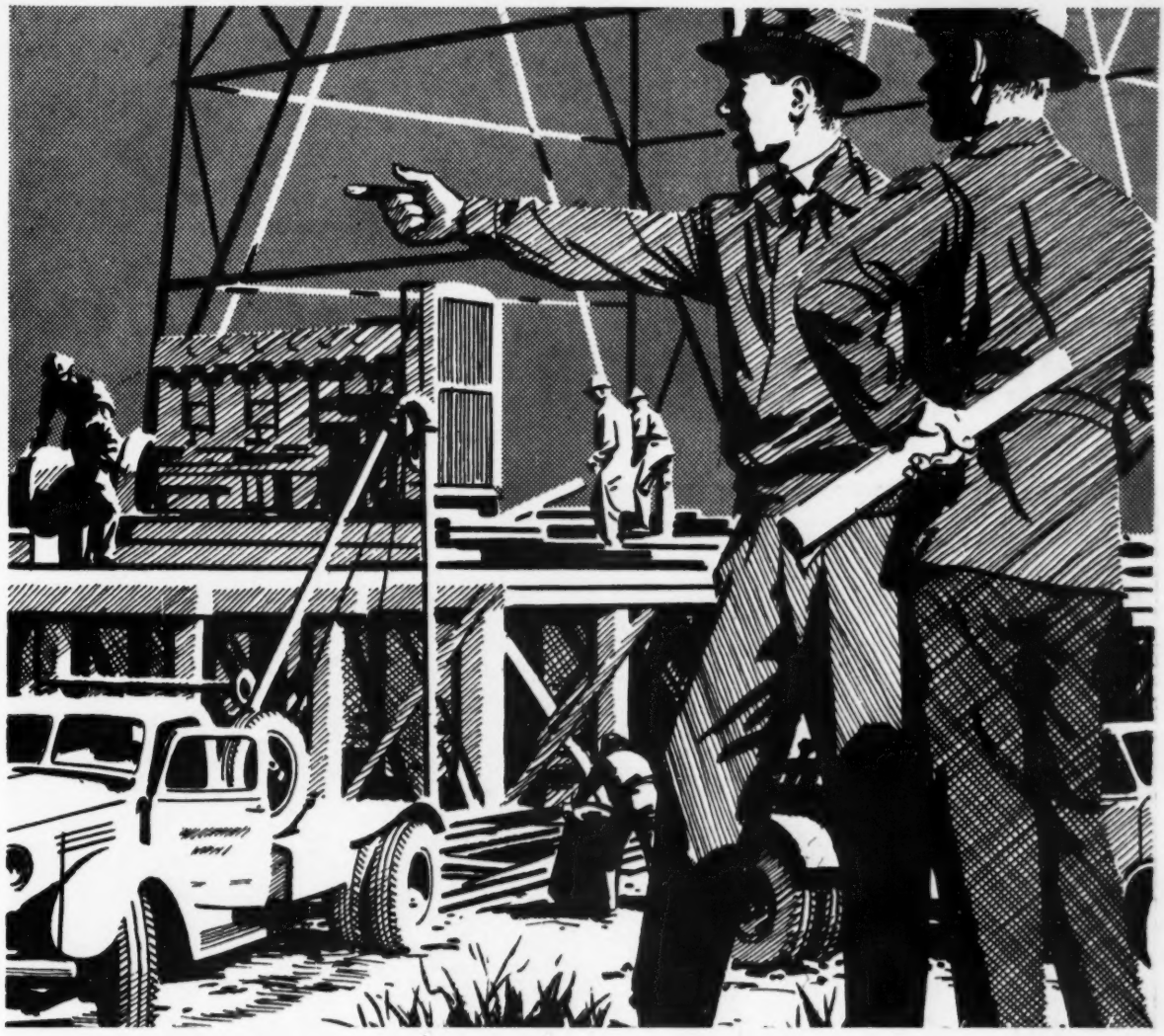

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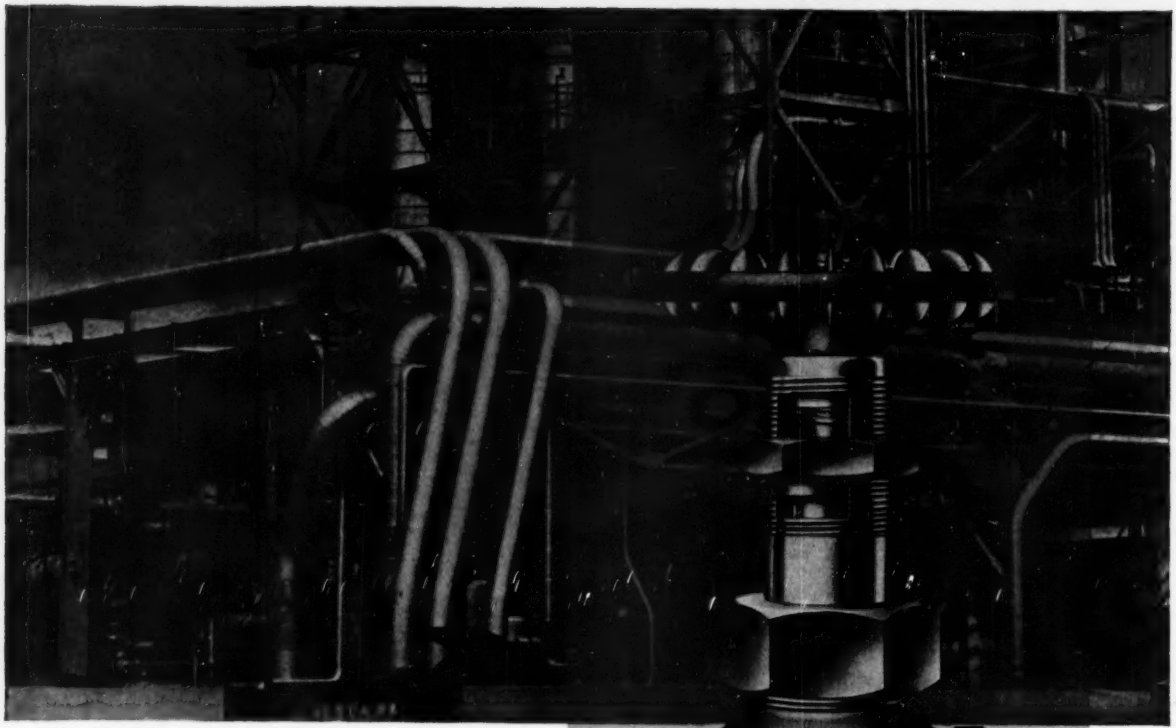

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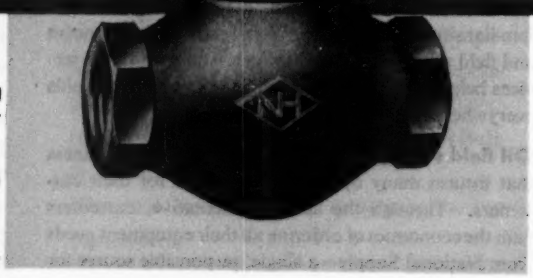

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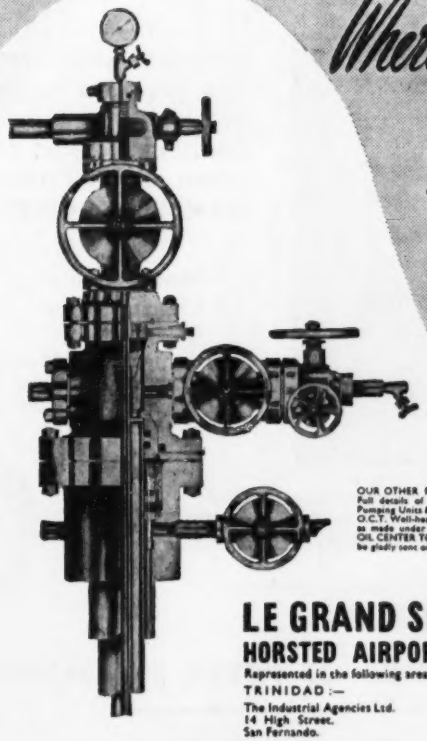

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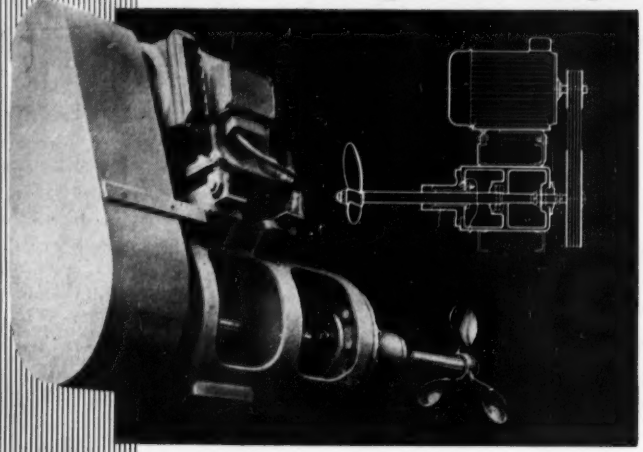

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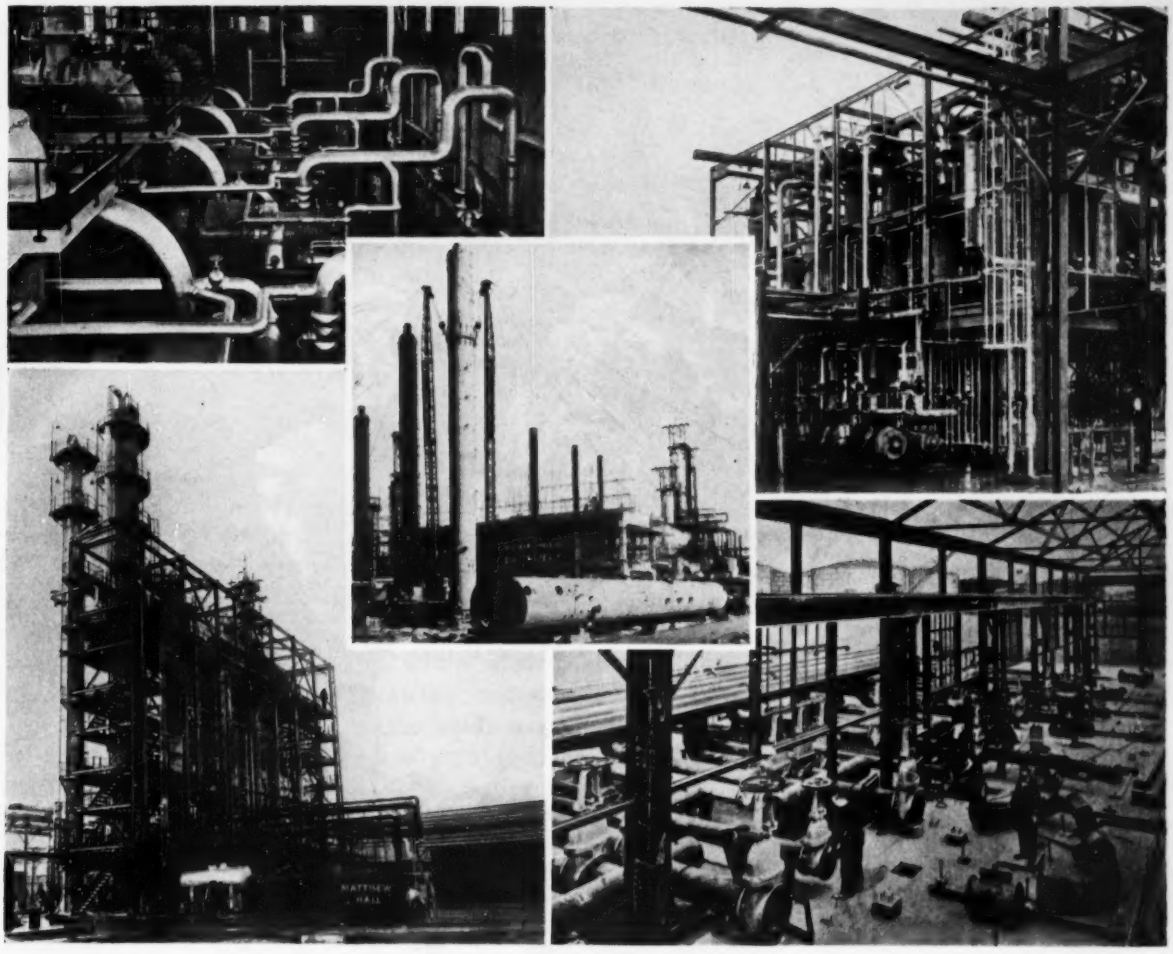

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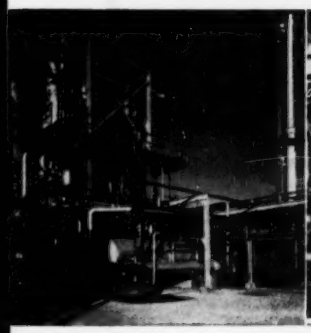
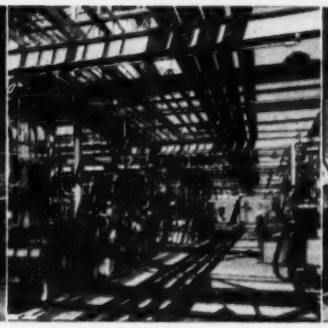
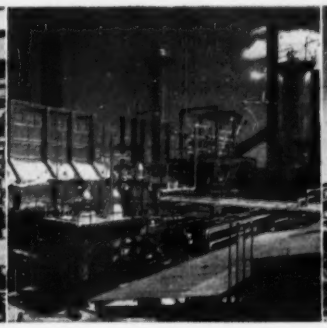
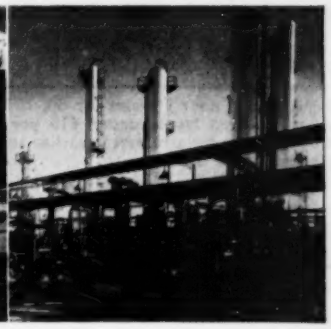

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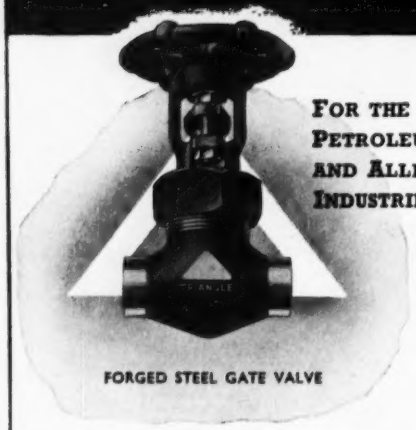

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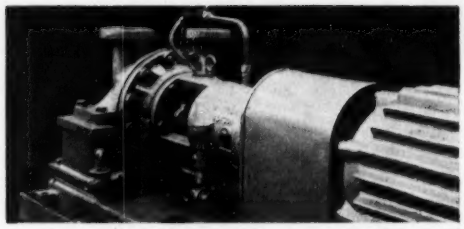

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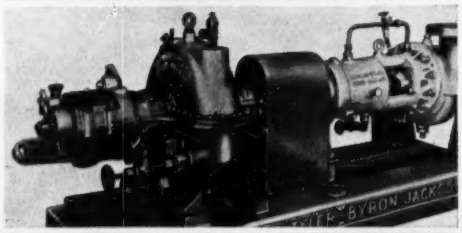

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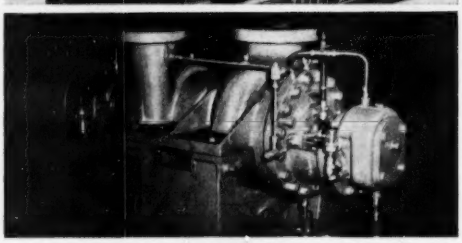

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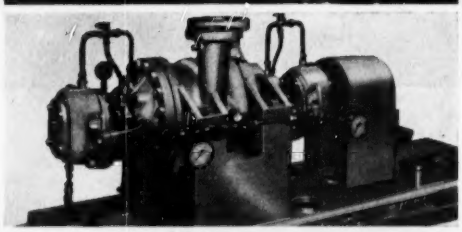

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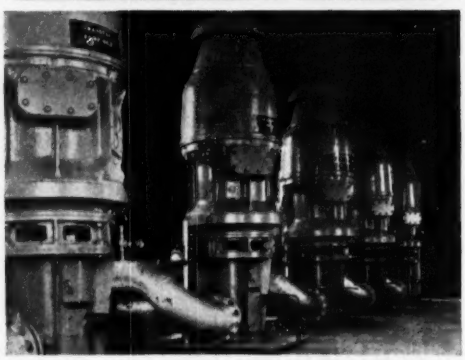

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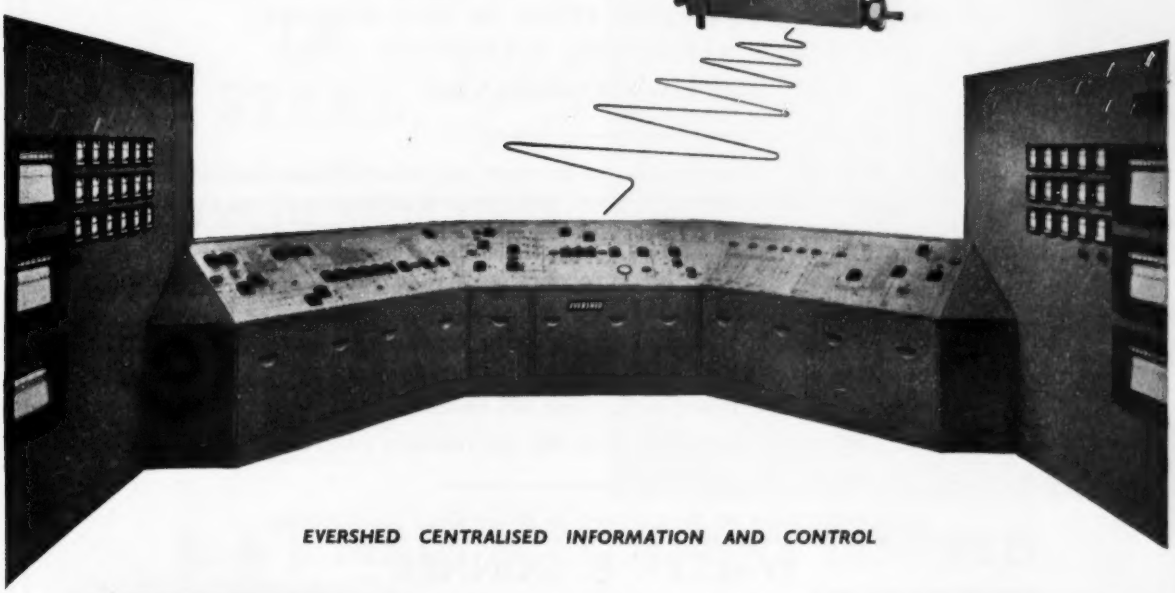

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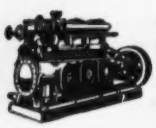

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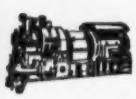

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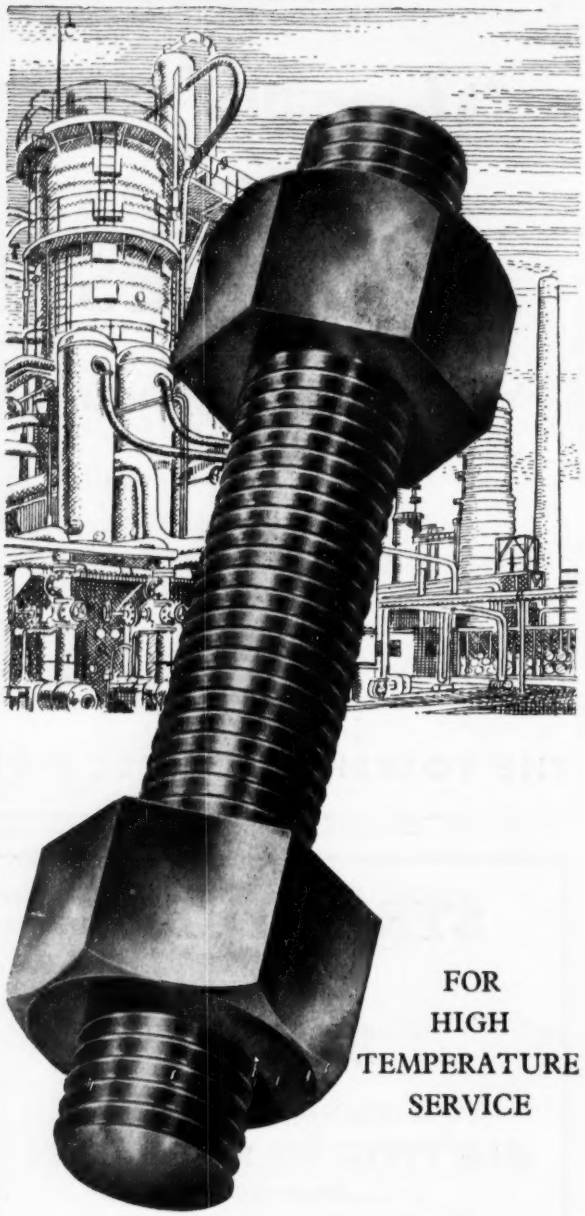

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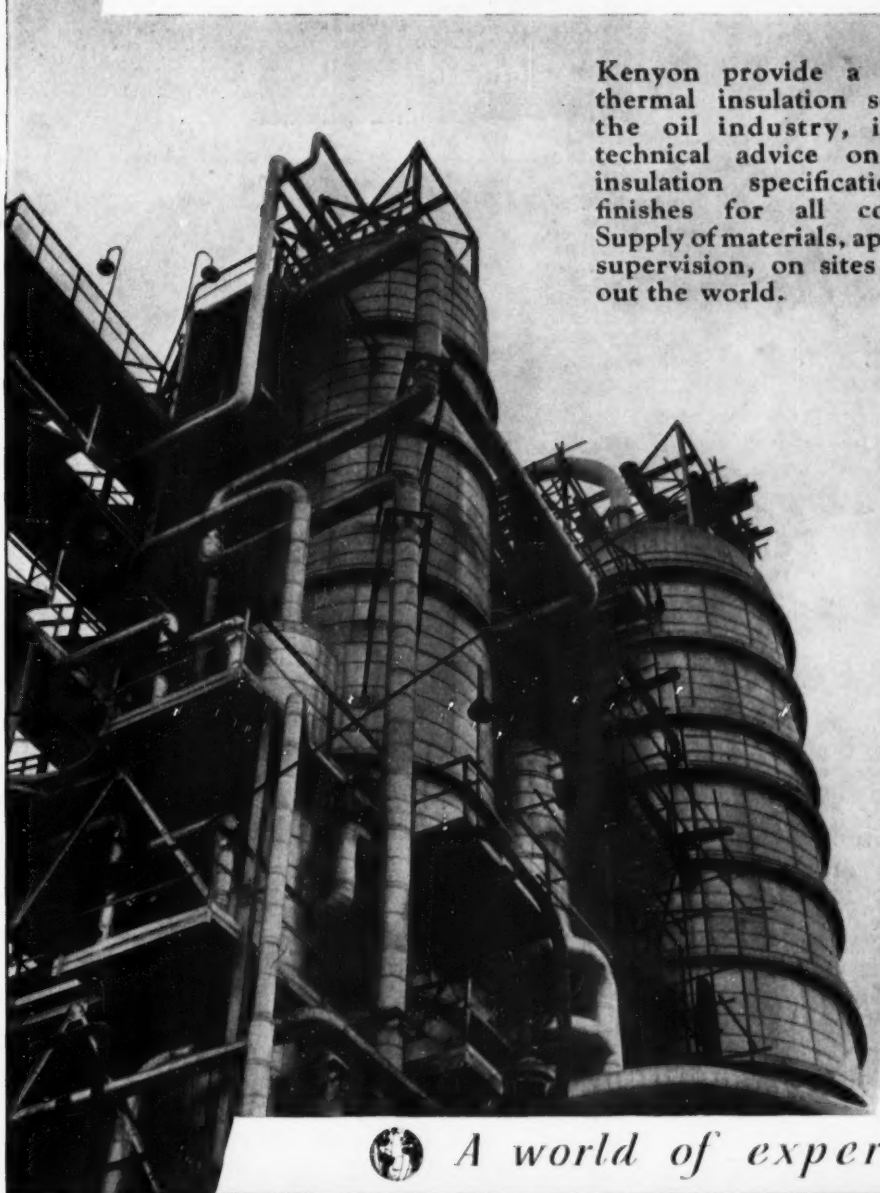

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Two Stage Distillation Unit

Photograph by courtesy of The Vacuum Oil Company, Coryton Refinery

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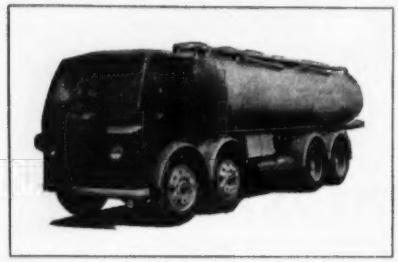
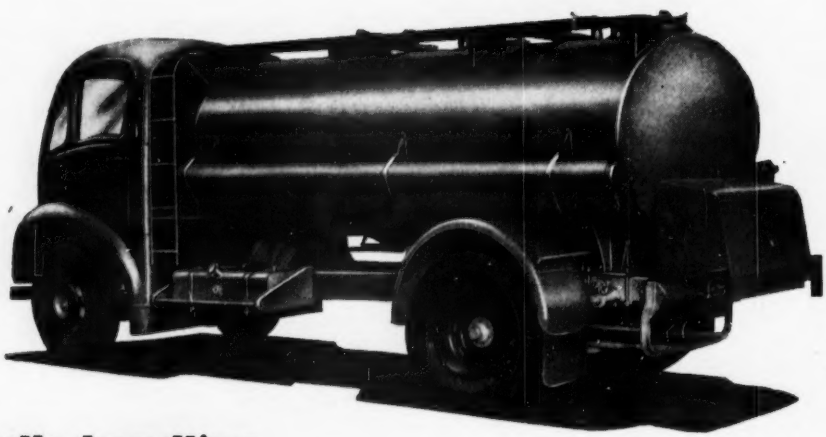
Illustrations show two Mild Steel tanks for petroleum spirit.



BUTTERFIELD Road tanks



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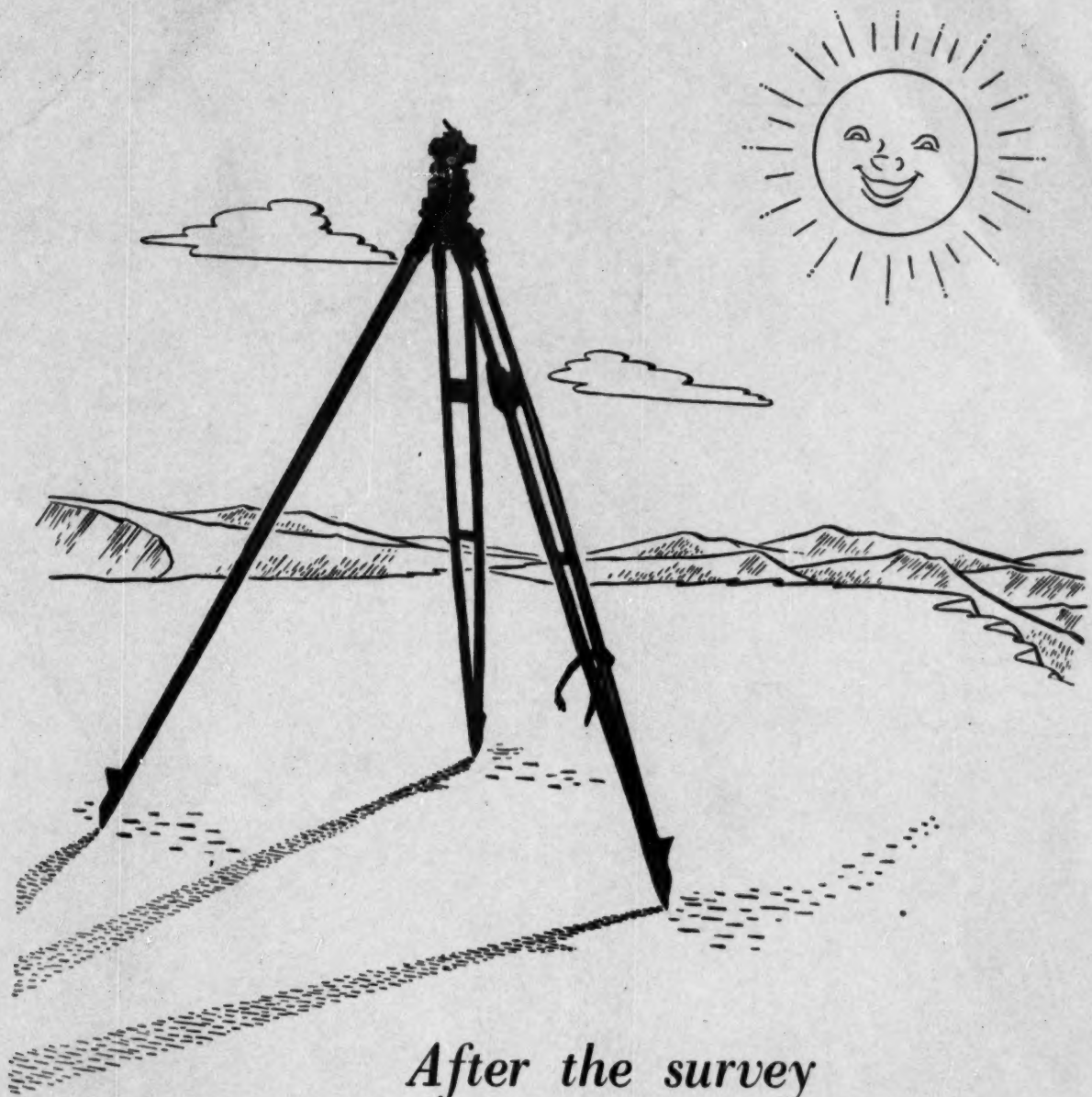

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